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SURVEY METHODS

FOR SOME

ECONOMIC INSECTS

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UNITED STATES DEPARTMENT OF AGRICULTURE

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Compiled by
Plant Pest Control Division
Agricultural Research Service
United States Department of Agriculture
Hyattsville, Md. 20782

CONTENTS

SURVEY METHODS FOR SOME ECONOMIC INSECTS

INTRODUCTION

These survey methods are intended to help entomologists evaluate insect populations more accurately. Over 80 methods are grouped according to cereal and forage, cotton, forest, fruit, livestock, soybeans, stored products, sugarcane, tobacco, and vegetables. Major sections are arranged alphabetically. These are further divided into specific crops. There is also a section on equipment and techniques.

The need to develop uniform methods to measure pest populations and the damage caused by them has long been recognized. Observations based on individual assessment and expressed in abstract terms, such as light, medium, or heavy, have little meaning but those based on numerical measurement have real meaning. Proven methods provide a common yardstick for evaluating insect infestation levels and serve as a basis for practical control. They also may be used as a guide to measure pest damage and to determine the amount of loss.

A separate compilation entitled "Survey Methods" was issued in 1953. Revisions appeared in 1955 and 1958. The present publication is the result of a demand by survey entomologists for a further revision. Additional methods and refinements in techniques have been included.

The Plant Pest Control Division is concerned with control or containment of a number of pests. Surveys have been published in U.S. Plant Pest Control Survey Manuals 1/ for the following pests: Beet leafhopper, burrowing nematode, cereal leaf beetle, citrus blackfly, European chafer, golden nematode, gypsy moth, Hall scale, imported fire ant, Japanese beetle, khapra beetle, Mediterranean fruit fly, Mexican fruit fly, Mormon cricket, potato psyllid, soybean cyst nematode, sweetpotato weevil, and white-fringed beetles.

Boll weevil, pink bollworm, and grasshoppers are included in this compilation as these insects are widespread and surveys may be conducted outside of the Division's activities.

1/ Available to plant pest control workers and cooperators from Plant Pest Control Division, Agricultural Research Service, U.S. Department of Agriculture, Federal Center Building, Hyattsville, Md. 20782

Corn and Sorghum

European Corn Borer

Elmer W. Beck [2]

Abundance Survey

The recommended procedure for making the European corn borer (Ostrinia nubilalis (Hübner)) fall abundance survey is to make 10 observations, or sample counts, per county. If it is found that contiguous counties cannot be sampled by utilizing 10 counts per county, a survey on a district basis is preferred, which averages about five counts per county. Fewer than five counts per county is not recommended.

An observation or sample count is obtained in a prescribed manner. The locations of the sampling points are distributed uniformly by marking them on a map of the area to be surveyed. The observer is instructed to proceed to the point marked on the map and to sample the first cornfield encountered. The sample is obtained after walking 50 paces into the field from the most accessible point. Beginning with the first plant on the observer's right, 25 consecutive plants are examined for infestation and the number of infested plants recorded. The last two infested plants encountered in the count of 25 are dissected, and the number and stages of borers found recorded. The product of percent infestation and of average borers per plant becomes the estimate of the field population expressed as borers per 100 plants. The observer then proceeds to the next location so on throughout the survey.

Distribution Survey

The distribution surveys are less formalized than the abundance survey. In searching for new infestations, available time and number of observers are the limiting factors. Recommendations have been to examine as many fields as possible that are deemed most likely to harbor the borer. For example, midseason surveys should be made in earliest fields in the area under observation, and September or later surveys should be confined to late fields. Concentrations of borers, if present, are expected to be more abundant in the respective types of fields.

2/ Retired, formerly with Grain and Forage Insects Research Branch, Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture.

Instructions for Completing European Corn Borer Fall Infestation Survey Form PPC 3-10

Wallace C. Harding, Jr. [3]

Data from each field surveyed should be entered on Plant Pest Control Division Form PPC 3-10, August 1958, shown below.

PPC FORM 3-10
AUG. 1958

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
PLANT PEST CONTROL DIVISION
AND
COOPERATING STATE AGENCIES

EUROPEAN CORN BORER FALL INFESTATION SURVEY

Dist. No.	Field No.	Date	Field corn	Sweet corn	State	County
Number of plants infested in count of 25			Condition			

Number of borers, by stage and instar, in two infested plants.	1. I	II	III	IV	V	P.	E.	Total
	2. I	II	III	IV	V	P.	E.	Total

Number stalks broken above ear. Other than tassel.	Number stalks broken below ear	Number of ears on ground
Percent plants infested	Per infested plant	Borers per 100 plants

Notes:

____________________ Observer

Line 1. (a) Enter date and number of district and field surveyed. (b) Check whether field corn or sweet corn, and name the State and county.

Line 2. (a) Record number of plants infested out of the 25 examined (infested plants usually show broken stalks or tassels along with typical larval frass). (b) Describe briefly the general condition of the crop such as the amount of lodging, of insect infestation other than borer, and of weeds.

Lines 3 and 4. (a) Record number of larvae under the appropriate instar (I through V) present in the first two infested plants. (b) Total number of larvae for each infested plant. (Note: One or both of these figures may be negative depending upon whether or not borers are present in the stalks. Pupae may be counted but eggs and dead larvae should be disregarded.)

Line 5. Fill in numbers of infested plants with stalks broken above and below ears and also number of ears on ground.

Line 6. (a) Determine and enter the percent of plants infested by multiplying the number of infested plants (line 2) by 4. (b) Enter number of borers per infested plant. This is obtained by averaging the two totals in lines 3

3/ Department of Entomology, University of Maryland, College Park, Md.

and 4. Finally, enter the number of borers per 100 plants. This is derived by multiplying the percent of plants infested by number per infested plant.

Estimates of Damage by the European Corn Borer to Grain Corn in the United States

Plant Pest Control Division 4/

Damage estimates to grain corn by the European corn borer (*Ostrinia nubilalis* (Hubner)) are prepared by using production data and crop values released by the Crop Reporting Board, Statistical Reporting Service, USDA. The basis for these loss estimates is determined by the survey of European corn borer populations during the fall of the year for which estimates are being made. An established index of 3 percent loss per borer per plant is used to compute the loss in bushels.

Procedure

Losses to grain corn by European corn borer are calculated by using the following categories:

(A) Production in thousands of bushels.
(B) Average price received by farmers for the season.
(C) Percent production for district, county, or State.
(D) Estimated production in thousands of bushels (A multiplied by C).
(E) Borers per 100 plants.
(F) Percent loss (E multiplied by 0.03).
(G) Percent production (100 minus F).
(H) Potential production (D divided by G).
(I) Loss in thousands of bushels (H minus D).
(J) Loss in thousands of dollars (B multiplied by I).

Total production of corn for grain (A) and the season average price per bushel (B) are obtained from the Federal or local crop reporting service. Percent production (C) of the total (A) for a given district or county is determined at the State or local level. Estimated production in thousands of bushels (D) for the district or county is obtained by using the percent production (C) for that district or county. Borers per 100 plants (E) are determined during the fall survey for the year for which losses are being determined. Percent loss (F) is obtained by multiplying the number of borers per 100 plants (E) by the established loss index of 3 percent per borer per plant. Percent production for the district or county (G) is the result of subtracting the percent loss (F) from 100 (percent), the potential production. The potential production (H or 100 percent), had there been no loss from the European corn borer, is determined by dividing the estimated production in thousands of bushels (D) by the actual percent production (G). The loss in thousands of bushels (I) is the result of subtracting the estimated production (D) from the potential production (H). The loss in dollars (J) then is obtained by multiplying this figure (I) by the average price per bushel (B).

4/ Agricultural Research Service, U.S. Department of Agriculture.

Calculations

A State produced an estimated 2,318,000 bushels of corn (A), and farmers received $1.35 per bushel (B) for a given year. The northeast district produced 35 percent (C), or 811,300 bushels (D) of this total. The number of borers per 100 plants (E) for this district was 215. Therefore, the percent loss (F) from the European corn borer was 215 multiplied by 0.03, or 6.45. Percent production for this district (G) was 100 minus 6.45, or 93.55. The potential production (H) was, therefore, 867,240 bushels, or 811,300 bushels (D) divided by 93.55 percent (G), had there not been a 6.45-percent loss because of the borer. Total loss in bushels (I) is then 867,240 minus 811,300 (H minus D), or 55,940 bushels. This figure (I) multiplied by $1.35 per bushel (B) gives a monetary loss (J) of $75,520.

Southwestern Corn Borer

W. A. Douglas [5/]

Various methods of selecting areas to be sampled for losses caused by the southwestern corn borer (*Diatraea grandiosella* Dyar) have been used. Generally, the most convenient method is to enter a field near the center of the most accessible side, walk 25 paces into the field, and start with sample No. 1 by taking 10 consecutive plants on a row. The second sample should be located by moving 25 paces toward the center of the field from the first location. Subsequent locations should be determined by the same method until five locations and a total of 50 plants have been sampled.

The State is divided into districts. A certain number of fields is taken from each district. The number of fields per district is determined by corn acreage in the district.

A formula for percent loss caused by the southwestern corn borer was based on a study conducted by C. A. Henderson. Data of losses were taken in 1962, 1963, and 1964. He found that borer tunneling caused a loss of 55 grams per stalk. If a plant was girdled and on the ground, the stalk was a complete loss when harvested by a mechanical harvester.

Formula for percent loss per field:

$$\frac{227 \text{ multiplied by number of girdled plus } 55 \text{ multiplied by number of infested}}{11{,}350}$$

The average weight of ear corn per plant when uninfested was 227 g. The average weight of ear corn per plant when infested was 172 g. Therefore, borer tunneling caused on the average a loss of 55 g. per plant--11,350 g. equals the number of grams that 50 uninfested plants would yield.

5/ Grain and Forage Insects Research Branch, Entomology Research Division, ARS, USDA, State College, Miss.

Corn Earworm

H. C. Cox, K. J. Starks, W. W. McMillian, and W. A. Douglas [6/]

Corn production data for use in determining corn earworm (Heliothis zea (Boddie)) damage are obtained from the Federal-State Crop Reporting Board, Statistical Reporting Service, USDA, which has headquarters in each State. On the average, one field is examined for each 700,000 bushels of corn produced during the 5 years immediately before the survey.

Specific cornfields within a district are determined before the start of the survey by placing dots, each representing a field, along the main highways on a road map. A commercial map obtained from oil companies is preferred to the official State Highway Department map from each State, because the commercial map is usually more detailed and, therefore, useful in estimating mileage between fields or distance of fields from towns. Dots, representing cornfields, are placed along main highways. Considerable time is saved by limiting travel to main highways rather than including the secondary highways. Occasionally, during the course of a survey, when no cornfield is found in the vicinity of the dot on the map, travel is continued in the same direction and the first cornfield encountered is surveyed. However, when such a field occurs in another crop-reporting district, the course of travel is reversed.

Each field is entered near the center of the most accessible side, usually the side near the road. The first sampling site is located by walking into the field 25 paces from the margin. Observations are made on the top ears of 10 consecutive plants beginning with the first plant on the right in front of the observer, depending on the direction of the row. After a general examination of the field, the husks are pulled back from each ear of corn to be observed and the following information is recorded: (1) Date, (2) location of field in State, (3) row width, (4) number of plants per acre, (5) number of ears per plant, (6) kernel color, (7) earworm damage class, and (8) notes on miscellaneous items such as cultural practices and weeds.

After observations on the last plant at the first sampling site are recorded, the second sampling site is selected by walking 20 paces toward the center of the field from the first site. Data are again obtained on items 7 and 8 above. The same procedure is repeated for subsequent sampling sites until 50 ears (10 ears each from five sampling sites) are examined in each field.

After the field is surveyed, the dot on the map is crossed off. The field number recorded on the survey data sheet is also recorded on the map beside the dot. Maps are filed for future reference.

6/ Grain and Forage Insects Research Branch, Entomology Research Division, ARS, USDA, Tifton, Ga., Serene, Uganda, Tifton, Ga., and State College, Miss., respectively.

The following table of damage classes was first determined by R. A. Blanchard 7/ after grading several thousand ears of corn damaged by the corn earworm:

Class	0	1	2	3	4	5
Penetration, inches	0	0 to 0.4	0.4 to 1	1 to 2	2 to 3	over 3
Loss, percent	0	0.44	1.87	4.10	7.87	16.55

A number of hybrids and open-pollinated lines were included in the study. Mr. Blanchard and the authors are aware that the true percentage of loss, when measured on a depth of penetration basis, depends on the size of the ear. They believe, however, that the system is the best approximation of true damage when limitations must be placed on time, personnel, and funds. All measurements of actual earworm penetration are made beginning with the first kernels of the ear, not with the tip of the ear.

Corn Earworm on Dent Corn

M. C. Wilson, G. E. Gould, R. T. Everly, and D. L. Schuder 8/

Survey Methods Used in Indiana

Entomologists in Indiana have been attempting to obtain an estimate of the fall infestation and damage of the corn earworm (Heliothis zea (Boddie)) to dent corn. This has been done by making an earworm survey along with the annual European corn borer survey.

Methods

For the survey of corn earworm damage, 200 sampling sites were selected as follows: The State of Indiana was divided into 11 regions depending upon location and soil types. Each region consisted of seven to 10 counties. The 200 sampling sites were then divided among the regions proportionately according to the corn acreage. In this way, the northwest central region, consisting of seven counties with the highest corn acreage, was apportioned 25 sampling sites. The southeast region also consisting of seven counties had only seven sampling sites, because of its much lower corn acreage.

Sampling sites were predetermined in each region and marked on a map so that the entomologists making the survey obtained the sample by driving directly to the location and sampling the cornfield nearest to the site. In predetermining the sampling sites, an attempt was made to proportion the fields accordingly in areas of muck, loan, and sandy soil types.

7/ Formerly of the Entomology Research Division, ARS, USDA.
8/ Department of Entomology, Purdue University, Lafayette, Ind.

Fields were sampled by walking 50 paces into the field and then examining the ears of 25 consecutive plants. Any ear that had been damaged by the earworm whether the insect was still present or not was considered infested. The first two infested ears were removed and the number of destroyed kernels on each ear counted. Allowances were made for small kernels near the terminal end of the ear that might not be expected to develop under normal conditions. The data from these two ears were averaged, and a percentage loss calculated based upon the average total number of kernels per ear from two representative uninfested ears selected from the field. There was very little variation in the number of kernels per ear in a variety in a field. Regional data were determined by averaging all fields in the district.

Corn Rootworms

O. H. Hammer 9/, C. E. White 10/, and L. L. Peters 11/

A survey method was developed for the survey entomologist to aid in making a reasonably accurate estimate of the damage and corresponding loss of field corn caused by corn rootworms (Diabrotica spp.). This survey concerns the loss caused by the larval stage.

While accuracy is not 100 percent, the additional time required to gain 100-percent accuracy is not justified when 90- to 95-percent accuracy may be attained with the amount of time available to the survey entomologist. Specialized and often expensive equipment is not needed to apply the method described.

Timing of Survey

Timing of this survey is not critical. The longer the survey is delayed, the more accurate it will be. Kernels should be fully developed though not necessarily dented. The best time for rootworm surveys is in the fall before the European corn borer-corn earworm survey.

Selecting the Fields

Examine at least 20 fields per district; more, if time permits. Fields should be as evenly distributed over the district as possible. The number of fields or Crop Reporting Districts examined is left to the discretion of the survey entomologist. The number will vary according to crop distribution.

9/ Dow Chemical Company, Bio-Products Center, Midland, Mich.
10/ Department of Entomology, University of Illinois, Urbana, Ill.
11/ Department of Entomology, University of Missouri, Columbia, Mo.

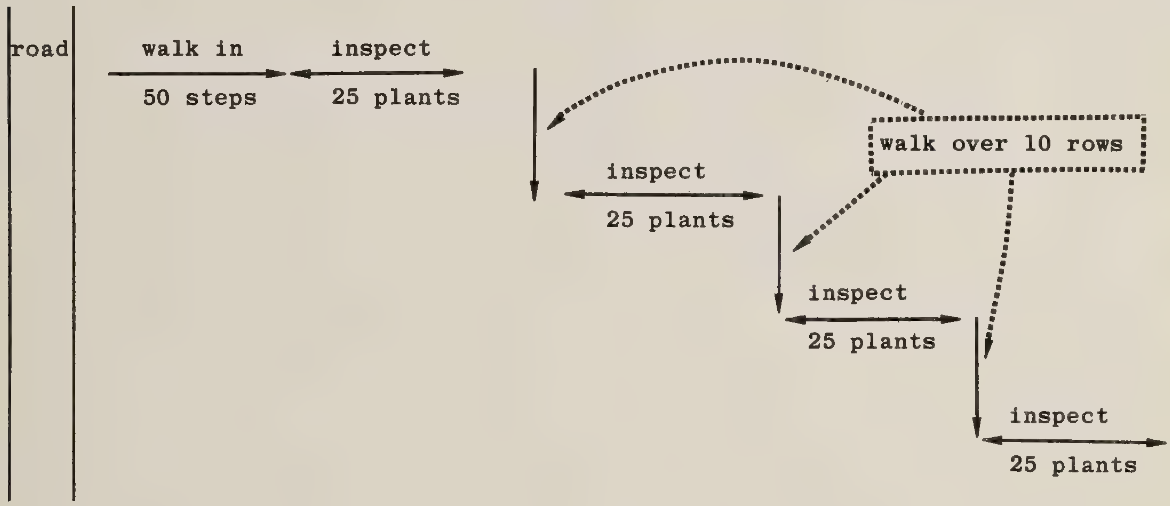
Forms for Recording Field Data

A standard method of recording the field data, which facilitates entry of field notes and transfer of data from the field log, is shown on page 12.

Method of Survey

Obtain sample by walking 50 steps into the field from the most accessible point. At this point, begin with the first 25 plants on your right, observe and record the number of rootworm-lodged plants. A lodged plant is one that is 2 inches off center at about 1 foot above the ground. Move to the right 10 rows from the last plant observed and record the same data for the next 25 plants. Continue this until 100 plants have been examined.

(Example of method of survey.)



CAUTION: Examine roots of a few plants to make certain that lodging is caused by corn rootworms and not by other factors such as excess water or herbicides. Rootworm-damaged roots will have gouges and tunnels and will have several rings of roots partly or completely destroyed.

In each group of 25 plants, estimate and record the number of kernels on one ear from one straight and one rootworm-infested lodged plant. The plants should preferably be growing side by side. If adjacent plants cannot be used, select straight plants growing as close to the lodged plants as possible. If 100 percent of the plants are lodged in the field, use this field as a record for lodged plants only and disregard straight plants for this field. The kernel count data may also be used to supplement the data collected for the corn earworm damage survey 12/. To estimate the kernels on an ear, count the number of kernels on an average row on the ear and multiply by the number of rows on the ear.

12/ U.S. Dept. Agr. Coop. Econ. Insect Rpt. 13(16):420-422, 1963.

Loss Calculation

The losses are best calculated on a district basis. Losses from all districts are added together to get the total loss for the State. The method of calculation is as follows:

1. Add together the number of plants lodged because of rootworms from all four groups of 25, in each field, and enter into the percent column on the recording sheet.

2. Add together the number of kernels per ear on lodged plants. Divide by four and enter into the average column for lodged plants. Do the same for the straight plants.

3. Total the percent columns and average kernel count columns for the district and divide by the number of fields examined. For average kernel count of lodged plants use number of fields infested.

4. $$100 \text{ percent minus } \frac{\text{Estimated kernels per ear, lodged plants, average}}{\text{Estimated kernels per ear, straight plants, average}} \text{ X } 100 \text{ equals percent reduction per infested plant}$$

5. Percent reduction X percent plants infested equals percent loss for all fields in District.

6. $$\left(\frac{\text{Crop Reporting Service total yield for District (bushels)}}{\text{100 percent minus percent loss}}\right) \text{ minus } \left(\text{Crop Reporting Service total yield for District (bushels)}\right) \text{ equals bushel loss for District}$$

7. Sum total district losses (bushels) X unit value (dollars per bushel) equals total State loss ($).

See example given on following page. Circled numbers refer to corresponding numbers above. Use the 20 fields on sample chart as an example of one district.

Field	Percent (1)	Average estimated kernels per ear on lodged plants (2)	Average estimated kernels per ear on straight plants (2)
1	9	517	701
2	37	536	688
3	15	684	716
etc.	etc.	etc.	etc.
20	$\frac{216}{20}$ = 10.8 (3)	$\frac{6,558}{13}$ = 504 (3)	$\frac{14,355}{20}$ = 718 (3)

(4) 100 percent minus $\frac{504 \text{ X } 100}{718}$ equals 100 percent minus 70 percent equals 30 percent reduction per lodged plant.

(5) 30 percent X 10.8 percent equals 3 percent yield loss all fields.

(6) From Crop Reporting Service for District:

Average yield per acre equals 50 bushels.
100,000 acres harvested yield for district equals 100,000 X 50 equals 5 million bushels.

$\frac{\text{5 million bushels}}{\text{100 percent minus 3 percent}}$ minus 5 million bushels equals 154,639

bushel loss for District.

CORN ROOTWORM (*Diabrotica* spp.) LOSS SURVEY ____________ (State)

DISTRICT ____________ DATE ____________ 19___ OBSERVER ____________________

Field No.	Plants Lodged					Estimated Kernel Count									
	Number					Lodged Plants					Straight Plants				
	Group I	Group II	Group III	Group IV	Percent	I	II	III	IV	Av.	I	II	III	IV	Av.
1	2	2	1	4	9	320	540	612	594	517	680	588	702	832	701
2	13	7	5	12	37	240	209	320	576	336	858	704	564	624	688
3	4	7	1	3	15	720	612	510	432	569	684	697	600	882	716
4	0	0	0	0	0					---	784	860	880	828	838
5	1	0	9	1	11	656		630	684	657	792	760	448	940	735
6	0	0	0	0	0					---	936	1000	616	752	826
7	0	0	0	0	0					---	770	720	936	846	818
8	0	0	0	0						---	688	592	784	840	726
9	7	8	0	3	18	624	504		836	655	858	574	924	720	769
10	0	0	0	0	0					---	864	768	665	672	742
11	0	0	0	0	0					---	738	630	820	828	754
12	5	1	11	13	30	336	506	680	360	471	792	490	720	612	654
13	0	0	0	0	0					---	656	784	848	880	792
14	0	0	3	1	4			672	736	704	864	752	704	648	742
15	5	9	10	6	30	504	99	300	656	390	616	558	630	656	615
16	2	0	0	13	15	544			736	640	616	688	720	820	711
17	4	0	0	6	10	234			336	285	656	640	630	546	618
18	0	5	0	4	9		595		304	450	592	672	608	465	584
19	5	0	3	0	8	476		416		446	532	459	828	774	648
20	2	6	7	5	20	528	532	255	437	438	748	704	800	448	678
					216					6558					14355

Insects Found in Corn and Sorghum Fields

C. E. White 13/, O. H. Hammer 14/, and L. L. Peters 15/

Survey Method for Insects Found Above Ground

Count all insects found on 25 (100 to 200 in a few cases) consecutive plants, plant whorls, ears, or heads, depending on the feeding habits. Determine and report the percent of plants or parts of plants that are infested or damaged and the number of insects per 100 plants or parts of plants. Determine the number of larvae on or in two infested plants then multiply percent of plants infested times 100 to get the number per 100 plants. This method is used for corn flea beetle, Japanese beetle adults, chinch bugs, corn rootworm adults, corn earworm (100 to 200 plants, if checking whorl feeding), fall armyworm (100 to 200 plants, if checking whorl feeding), armyworm, grasshoppers, corn leaf aphid (estimated number per tassel, whorl or leaf), thrips, European corn borer egg masses, European corn borer, and other stalk-boring larvae.

Survey Method for Insects Found Below Ground Level

This survey method is designed to determine insect abundance and stand damage. The method is used mainly for early season work when the plants are small. Determine the percent of plants damaged by examining 100 consecutive plants at two places (200 plants in all) 25 to 50 rows apart. In heavy infestations where possibly a fourth or a fifth of the plants are damaged, an examination of 25 plants at each place should be sufficient.

Examine the plants rapidly as you walk along the row. Look for plants that are stunted, wilting, dying, or cut off. Determine the number of larvae per damaged plant by examining the roots and soil about the roots of at least two damaged plants in each group of the plants examined. To get the average number of larvae per 100 plants, multiply the average number of larvae per damaged plant by the percent of plants infested by 100. Report the percent of plants damaged and larvae per damaged plant or per 100 plants. This method is used for cutworms, rootworms, white grubs, Japanese beetle larvae, *Colaspis* larvae, root aphids, and other root feeding insects.

Insects in Heads of Combine-Type Grain Sorghum

W. P. Boyer 16/

Survey Methods Used in Arkansas

The production of short stalk combine-type grain sorghum is on the increase in Arkansas. This results in the need for an insect survey method that can be used in the field by farmers, county agents, and entomologists.

13/ Department of Entomology, University of Illinois, Urbana, Ill.
14/ Dow Chemical Company, Bio-Products Center, Midland, Mich.
15/ Department of Entomology, University of Missouri, Columbia, Mo.
16/ Department of Entomology, University of Arkansas, Fayetteville, Ark.

Potential economic damage from several species of insects has been recognized for many years in Arkansas. Survey to evaluate insect populations was by field examination of the heads of the plants, without the use of any special equipment. The result was that many insects, especially small immature forms, fell to the ground and were not counted because of difficulty of recovery.

Buckley and Burkhardt 17/ demonstrated that corn earworm or bollworm (Heliothis zea (Boddie)) could cause severe damage to grain sorghum. This work showed the importance of accurately determining the population and the age of the larvae. Laster and Furr 18/ referred to the difficulty of recovering insects from the heads of sorghum without the use of special equipment. They developed a method to use in insecticide tests but the method required cutting off the heads of the plants.

A survey method for determining populations of insects in heads of combine-type grain sorghum was developed and used in Arkansas in 1965 (Boyer 19/). The method does not require cutting heads off the plants and removing them from the field for further examination.

The method involved the use of the soybean drop sheet as described by Boyer and Dumas 20/. In 1967 an improvement was made in the survey method by the development of a piece of equipment to replace the soybean drop sheet. Insects are counted in the field as was done with the drop sheet.

A cloth-covered frame (fig. 1) was designed and made to replace the drop sheet previously used. Legs attached to the frame are inserted in the surveyor's belt. The surveyor can work from a standing position or on his knees depending on the height of the surveyor and the crop. Soybean heads bent over the cloth frame are thoroughly opened, rubbed, and shaken to dislodge the insects that are easily caught and counted on the cloth.

Insect numbers per row foot are more meaningful than numbers per head or per 100 heads. Workers in Arkansas prefer the row foot count, and control recommendations are being developed on that basis. An example would be four bollworms to the row foot in 38- to 40-inch rows and three in 28- to 30-inch rows. Some producers in Arkansas are planting in narrow rows. Insect populations are determined by examining all the heads on 10 row feet at each of four randomly selected sites per field.

17/ Buckley, B. R., and Burkhardt, C. C. Corn earworm damage and loss in grain sorghum. Jour. Econ. Entom. 55(4): 435-439. 1962

18/ Laster, M. L., and Furr, R. E. A simple technique for recovering insects from sorghum heads in insecticide tests. Jour. Econ. Entom. 55(5): 798. 1962.

19/ Boyer, W. P. Survey method for insects in heads of combine-type grain sorghum. U.S. Dept. Agr. Coop. Econ. Insect Rpt. 16(23): 531-532. 1966

20/ Boyer, W. P., and Dumas, B. A. Soybean insect survey as used in Arkansas. U.S. Dept. Agr. Coop. Econ. Insect Rpt. 13(6): 91-92. 1963.

Figure 1.--A cloth-covered frame used in determining insects in heads of combine-type grain sorghum: A, Frame showing the legs which are inserted in the surveyor's belt as shown in B.

This method of survey has been successful in recovering small insects. For example, in 1965 by using the drop sheet, recovered bollworm larvae were preserved and measured. Various lengths were 0.25 inch, 26 percent; 0.5 inch, 32 percent; 0.75 inch, 25 percent; 1 inch, 13 percent; and over 1 inch, 4 percent. Head capsule measurements to determine instars were not made on all larvae. Measurements of most of the larger larvae showed them to be full grown. This indicated that larvae of this species in grain sorghum do not reach lengths of 1.5 inches or more as they often do in corn and cotton. In 1967 the use of the cloth-covered frame proved to be as successful or more so than the use of the drop sheet. This would be expected because of handling the heads at closer proximity to the cloth. Nymphs of the small important predator *Orius insidiosus* were easily recovered and counted. Even winged adults of this species were recovered and counted. *Orius* nymph counts are believed to be accurate. Accuracy of adult *Orius* counts was not compared with other methods.

In the case of some grain sorghum hybrids, the bases of some of the heads, under certain conditions, do not clear the sheath. This area under the sheath is a favorite location for small bollworm larvae and requires special attention by the surveyor. In one case, when small larvae were found at the rate of 13,000 per acre, more than 50 percent were found on the base of the heads under the sheath. A study made 2 weeks later showed that the bollworm and other species had apparently gained protection from predation in this location. Fifty heads that had cleared the sheath and 50 heads that had not--all randomly selected--were examined for insects. Results are presented in table 1. These data show the importance of checking under the sheaths of this type of sorghum.

Table 1.--Insects recovered from sorghum heads, 1965

Heads	Bollworm	Fall armyworm 1/	Sorghum webworm 2/	European Corn borer 3/
	Number	Number	Number	Number
50, cleared sheath	42	4	1	1
50, not cleared sheath	103	46	8	2

1/ *Spodoptera frugiperda* (J. E. Smith)
2/ *Celama sorghiella* (Riley).
3/ *Ostrinia nubilalis* (Hübner).

Insects Interfering with Corn Pollination

O. H. Hammer [21], C. E. White [22], and L. L. Peters [23]

A method was developed for use by survey entomologists to make a reasonably accurate estimate of the damage and corresponding loss to corn caused by insects that interfere with the pollination of the ear. Insects involved include corn rootworm adults (*Diabrotica* spp.), grasshoppers, corn earworm (*Heliothis zea* (Boddie)), Japanese beetle (*Popillia japonica* Newman), and corn leaf aphid (*Rhopalosiphum maidis* (Fitch)).

Timing of Survey

This survey can be made in conjunction with the corn rootworm loss survey or any time after the silks have dried.

Selecting the Site

If the corn rootworm loss survey is made, the same fields can be used for this survey. If not, examine at least 20 fields per district and more if time permits. Because of crop distribution, the number of fields examined will vary and will be at the discretion of the survey entomologist.

Forms for Recording Field Data

A standard method of recording the field data, facilitating entry of field notes, and transferring data from the field record are desirable. A suggested form is given at the end of this article.

Methods of Survey

Obtain samples by walking 50 steps into the field from the most accessible point. At this point, start with the first plant on your right, strip the shucks back on the next 25 ears in that row, and examine the ears for lack of pollination (kernels failing to set). Record number of ears damaged. On five damaged ears, estimate number of kernels present by counting the number of kernels on an average row on the ear and multiply by the number of rows on the ears and record. (If less than five ears are damaged, examine all ears damaged.) Estimate the number of kernels on the five nondamaged ears in the same manner and record.

If the corn rootworm loss survey is being made, go right 10 rows from the last sample and take the next 25 ears to obtain a more accurate figure for percent ears damaged. Also, record the number of ears damaged while making the rootworm survey. Examine total of 25 ears.

21/ Dow Chemical Company, Bio-Products Center, Midland, Mich.
22/ Department of Entomology, University of Illinois, Urbana, Ill.
23/ Department of Entomology, University of Missouri, Columbia, Mo.

Loss Calculation

The losses should be calculated on the district basis. Losses for all districts are totaled together to obtain the State loss.

1. Count and record the number of ears damaged and the kernels on five damaged and five nondamaged ears in the field.

2. $\frac{\text{Total ears damaged}}{\text{Total number ears examined}}$ X 100 equals percent ears damaged.

3. Obtain the average number of kernels for damaged and nondamaged ears <u>in each field</u>.

4. Total the "Average Estimated Kernel Count" columns and divide totals by number of fields examined. This equals the average number of kernels per damaged and nondamaged ear.

5. $$100 \text{ percent minus } \left(\frac{\text{Average number of kernels per damaged ears}}{\text{Average number of kernels per nondamaged ears}} \times 100 \right) \text{ equals percent reduction per damaged ear.}$$

6. Percent ears damaged X (percent reduction per damaged ear) equals percent loss all fields in district.

7. $$\left(\frac{\text{Crop Reporting Service total yield for district (bushels)}}{\text{100 percent minus percent loss}} \right) \text{ minus } \left(\text{Crop Reporting Service total yield for district (bushels)} \right) \text{ equals bushel loss for district.}$$

8. Sum total all district losses (bushels) X unit value (dollars per bushel) equals total State loss ($).

See example given below. Circled numbers refer to corresponding numbers in preceding paragraph. Use the sample chart at end of article as an example of one district.

Field	Ears damaged (1) No.	Percent		Average Estimated Kernel Count (1) Damaged ears	Nondamaged ears
				(3)	(3)
1	1	4		4	703
2	0	0		-	649
etc.	etc.	etc.		-	-
20	2	8	(2)	97 (4)	716 (4)
20	10	40/20	= 2 percent	451/4 = 113	13,451/20 = 673

(5) 100 percent minus $\frac{113 \text{ X } 100}{673}$ equals 83 percent.

(6) 2 percent X 83 percent equals 1.7 percent loss all fields.

(7) From Crop Reporting Service for district:

Average yield per acre equals 50 bushels
100,000 acres harvested yield for district equals 100,000 X 50 equals 5 million bushels

$\frac{\text{5 million bushels}}{\text{100 percent minus 1.7 percent}}$ minus 5 million bushels equals 86,469 bushel loss for district.

(8) Add all district losses together X unit value ($) equals State loss ($).

See table on following page.

INSECTS INTERFERING WITH CORN POLLINATION-LOSS SURVEY ________
(State)

DISTRICT ____________ DATE ________ 19 ____ OBSERVER ____________

Field No.	Ears Damaged			Estimated Kernel Count											
				Damaged Ears						Nondamaged Ears					
	No.	X 4	Per-cent	I	II	III	IV	V	Av.	I	II	III	IV	V	Av.
1	1	X 4	4	4	--	--	--	-	4	750	666	830	720	550	703
2	0		0							448	828	672	656	640	649
3	0		0							656	672	336	466	630	552
4	0		0							688	616	704	680	820	702
5	0		0							630	752	656	471	504	603
6	0		0							648	848	490	738	836	712
7	0		0							612	820	768	858	672	746
8	0		0							924	592	770	684	612	716
9	0		0							240	840	936	1000	792	762
10	0		0							432	320	540	752	448	498
11	0		0							860	684	336	594	828	660
12	3	X 4	12	250	120	350	--	--	240	688	574	660	828	654	729
13	0		0							600	704	680	774	608	673
14	0		0							640	616	390	736	506	578
15	0		0							546	720	558	864	360	610
16	0		0							624	656	704	784	792	712
17	0		0							880	720	630	864	654	750
18	4	X 4	16	124	150	76	88	--	110	450	608	546	840	936	698
19	0		0							656	828	666	574	688	682
20	2	X 4	8	90	104	--	--	--	97	702	624	600	860	792	716
	10	÷ 40/20 = 2%							÷ 451/4 = 113						÷ 13451/20 = 673

Alfalfa Caterpillar

R. F. Smith and W. W. Allen [24]

Sampling Methods as Used in California

Samples of the larval population of the alfalfa caterpillar (*Colias eurytheme* Boisduval) are taken by sweeps of a standard insect net. The lower edge of the net is held 8 to 10 inches into the alfalfa. As the sweeps are made, the rim of the net is held perpendicular to the ground. The sweeps are made through a half circle from one side of the sweeper to the other. A step is taken between each sweep. Normally a circle of the field will be made taking one- or two-sweep samples at frequent intervals. All types of growth, such as height, variety, color, ridges, between ridges, and "islands," should be sampled. Fields or parts of fields that grow more slowly than normal, for example those that remain in the one-fourth stage for a long time, should be watched carefully. When confirmation counts (check counts made to confirm previous predictions) are made, fewer samples, generally at a few specific spots, are taken. With experience one can estimate most of the counts. Only about every fifth sample is counted. Although some will take much more, 20 minutes per field is a good average. It is important to realize that slack periods occur between broods. Under conditions favorable for the caterpillar, a field may go from the oviposition stage to the injurious stage in 10 days or less. Routine visits are made to every field each week and such supplementary counts as seem necessary are made between visits.

Economic level of infestation.--The standard by which economic infestations are judged is a sliding scale centered around 200 nonparasitized larvae per 20 sweeps of the standard net. This "center point" is to be used for average conditions, which rarely exist. Other factors, such as growth, stand, and period remaining until harvest, must be taken into consideration. For example, this center point is too low for a dense vigorously growing alfalfa field and for infestations developing during cool weather.

Factors favoring damage.--The development of an economic population is favored by (a) large flights of adults when the alfalfa is short, (b) few short fields in the vicinity at time of flight, (c) slow or uneven growth to alfalfa, (d) insufficient parasites to reduce the population below the economic level, and (e) hot, dry weather.

24/ Department of Entomology and Parasitology, University of California, Berkeley, Calif.

Alfalfa Weevil [25]

C. C. Blickenstaff [26]

The numbers of eggs of the alfalfa weevil (Hypera postica (Gyllenhal)) present are not often reported because eggs are difficult to find and to conduct an adequate survey is very time consuming. Surveying for numbers of pupae entails the same problems. Activities of the adults are so greatly influenced by temperature and sunlight that sweep counts of the adults for comparative abundance are almost meaningless. Therefore, numerical reporting of these stages should not be attempted in general survey work.

The larval stages are relatively immobile, are concentrated in plant tips, and are in a stable stage for sampling. Hence, the larvae are easily swept and are the most readily available. Plant damage, easily detected and readily estimated in terms of percentage of foliage eaten, is of immediate use. Use of larval stages in plant tips and plant damage is recommended in all survey work with supporting observations of the presence and development of eggs, larvae, pupae, and adults.

Since timing control measures is often based on the percentage of tips infested, this information should be recorded during the early surveys. Plant height early in the season and stage of development late in the season, such as early bud and full bloom, should be recorded. For plant height, marks on the net handle are handy.

The recommended sampling procedures that follow are not based upon statistical evidence of adequacy. Until such data are available, we can only suggest procedures that, in our opinion and experience, would improve the current situation and at least allow for uniformity.

Supplemented by advice from extension entomologists at the University of Maryland, we recommend the reporting units and sampling procedures be as follows:

1. Percentage of tips infested (early in the season).--Examine 50 tips per field, taking five samples of 10 tips each.

2. Number of larvae per sweep.--Take 10 sweeps per sample and up to five samples per field with a minimum of three, depending upon severity of infestation and differences among counts. In surveying for new infestations to establish the presence or absence of larvae, use at least 100 sweeps per field in units of 10 sweeps.

3. Plant height in inches, and stage of development (early bud, midbloom, full bloom, stubble).

25/ Adapted from Blickenstaff, C. C. Standard survey procedures for the alfalfa weevil. Ent. Soc. Amer. Ann. Bul. 12(1): 29-30, 1966.

26/ Grain and Forage Insects Research Branch, Entomology Research Division, Agricultural Research Service, USDA, Bozeman, Mont.

4. Percentage of foliage eaten.--Estimate by visual observation at location of each sweep sample. Use increments of 10 percent; if foliage eaten is less than 10 percent, use smaller increments of 2, 4, 6, and 8 percent.

5. Whether treated with insecticide or not.

6. Descriptive statements on presence and abundance of eggs, pupae, and adults.

More information would be gained by surveying the same series of fields repeatedly throughout the season than by substituting new or different fields each time. It is important, however, that representative fields be chosen to start with. The number of fields on which averages are based should always be given.

We also recommend that the sweeping method be standardized as much as possible. The following suggestions are submitted to aid in attaining this goal:

1. Net: 15-inch diameter opening.
2. Sweep: 180° arc.

This type of survey would allow the following to be determined:

1. Timing of spring treatments.
2. Relative abundance of larvae from year to year and among areas affected.
3. Larval buildup and decline, and time and duration of damaging populations.
4. Development of larvae in relation to that of host plant.
5. General record of life history.
6. General effectiveness of controls.
7. Rough estimates of damage.

Clover Aphid

Carl Johansen [27]

The following sampling method for clover aphid (*Nearctaphis bakeri* (Cowen)) was developed for work in red clover fields in Washington State.

Early in the season (up until about July 1 in the Columbia Basin of Washington), the aphids will be found under the stipules; later, they will be under the bracts of the heads; still later, they will be throughout the heads and on the stems and foliage in heavy infestations. Ten-stipule or 10-head samples (depending upon seasonal development) are taken at random from five areas of the field--the four sides and the middle. Sometimes only the margins of the field are sampled, because these areas become infested first.

27/ Department of Entomology, Washington State University, Pullman, Wash.

With colonies of 25 aphids or less per stipule or head, actual counts are taken. When populations become high, the aphids are estimated in 5's or 10's. Such estimating can be done with good results if the stipules or heads are opened up and turned slowly while they are being counted. Individual heavily infested heads can be torn apart and the aphids counted as a check on the accuracy of estimations.

The figures for light, medium, and heavy clover aphid infestations in red clover grown for seed in Washington are dependent upon the time of hay cutting (table 1).

Table 1.--Number of clover aphids per 10 heads or stipules, Washington State

Degree of infestation	Weeks after hay cutting				
	3	4	5	6	7
Light	0 to 5	0 to 10	0 to 15	0 to 50	0 to 150
Medium	10 to 25	15 to 50	20 to 100	60 to 250	200 to 750
Heavy	25	75	200	500	1,000

The aphids are moving from the stipules to the heads during the fourth and fifth weeks after hay cutting. Starting in 1959, a treatment was recommended in this State during the fourth and fifth weeks after cutting, if a medium infestation was present. Because this level of infestation causes a reduction in yield, early treatment was found effective.

Pea Aphid

For survey of pea aphid, see Vegetable Insects, Peas and Beans, Pea Aphid by W. C. Cook on page 102.

Spotted Alfalfa Aphid

M. W. Nielson [28]

Habits

The spotted alfalfa aphid (Therioaphis maculata (Buckton)) prefers to feed on the underside of alfalfa leaves near the base of the plant. As the population increases, the insect will feed on stems and eventually work upward as the lower leaves are killed. The aphid will drop off the leaves when disturbed. Copious amounts of honeydew are produced by the aphid. When the plants are being killed, thus restricting food supply, the aphid will produce winged forms that migrate to other more attractive alfalfa fields. In the Southwest, reproduction is exclusively by parthenogenesis. Sexual forms are produced in the colder climates where the aphid overwinters in the egg stage.

Seasonal Abundance

In Arizona three distinct population peaks occur. Sometimes a fourth peak takes place in January. Usually the main population peaks occur in April, July, and October. Surveys and population counts should be taken just before the period when these population peaks are likely to occur.

Sampling

Sampling alfalfa fields with a sweepnet is useful only to determine the presence of the spotted alfalfa aphid in alfalfa. A simple, practical, and accurate method of estimating populations in the field is by the leaf-count system. Aphids are counted on three trifoliolate leaves, each selected at random from the top, middle, and bottom of plants. These subsamples should be repeated 10 times at random intervals of 20 to 50 walking steps diagonally across the field. Thirty trifoliolate leaves will thus represent the total sample from one field. Care should be taken during sampling to minimize disturbance and subsequent loss of aphids dropping from the leaves. To avoid loss, the leaf petiole is grasped by the thumb and forefinger and slowly turned until the entire underside of the leaf is clearly visible.

Resistant alfalfa varieties are recommended for control of the spotted alfalfa aphid. However, aphids will occasionally build up on seedlings of some resistant varieties. Treatment with recommended insecticides is necessary on all varieties when the aphid population reaches an average of one per seedling in seedling fields or five per trifoliolate leaf in older stands. One seedling is equivalent to a sample of one trifoliolate leaf of older plants. Thus, 30 seedlings should be included in the sample for alfalfa fields in the seedling stage. An alfalfa seedling is defined as that stage of the plant between the appearance of the unifoliate and the first trifoliolate leaves.

28/ Grain and Forage Insects Research Branch, Entomology Research Division, ARS, USDA, Mesa, Ariz.

Ladino Clover Seed Midge

H. W. Prescott [29]

Serious losses to Ladino clover seed production in Oregon have resulted from attacks by the Ladino clover seed midge (Dasineura gentneri Pritchard). Although the species was described in 1953, its distribution was still limited in 1967. The detecting of infestations is, therefore, of concern wherever Ladino clover is grown for seed. White and alsike clovers may also be infested by the insect.

In new clover fields, infestations build up gradually and may not reach a peak until the second year of seed production. The presence of midge cocoons on the soil surface under vegetation and debris is a valuable indicator of infestation past or present. Even the empty cocoons or their recognizable fragments may be in evidence for a year or two after the adults have left them. While adults or immature stages of this insect infesting clover are present only at certain times of the year, the cocoons accumulate in infested fields. The cocoons always will be sufficiently abundant to be found readily in fields that have at any time within the previous 2 or 3 years carried infestations of economic intensity. The use of cocoons to indicate an infestation makes possible the inspection of fields for infestation at any time of the year when the ground is not frozen or covered with snow. However, this method will often fail to reveal extremely light infestations such as those occurring in new clover plantings or those in heavily pastured clover.

The cocoons are oblong, light gray to white, slightly under 1/16-inch wide, and only slightly longer. Though small, their light color makes them easily visible. They occur in greatest numbers in depressions in the ground where compacted vegetation trash has accumulated. Usually they are most abundant in the shallow irrigation trenches known as "corrugations," especially in older fields where protective layers of well-compacted trash have had time to accumulate.

Detection of infestations in clover fields by sweeping with a net for the adults is rapid and convenient but the method has certain limitations. If no adults are taken in the net, it may mean that (1) there is no infestation, (2) the infestation is not in the adult stage, or (3) conditions are such that the net is not catching the adults when present. The first emergence of adults from overwintering cocoons coincides closely with the appearance of bloom on the clover.

In central Oregon, from early June until the seed crop is harvested in early September, three broods of adults appear each about a month apart. Emergence of each brood requires roughly 2 weeks. The emergence periods are separated by an interval of approximately 2 weeks during which few or no adults are present in the fields. Sweeps taken during these intervals may give a

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[29] Retired, formerly with Entomology Research Division, ARS, USDA, Forest Grove, Oreg.

negative indication, even where heavy infestations exist. Wind causes adults to go deep into the vegetation for shelter. Net sweeps on windy days, especially in deep vegetation, may give negative results. This is likely to be the case when moderate to low adult populations are present. Adults are most abundant on the upper surfaces of the plants around midday when the sun is highest.

In sweeps repeated at intervals throughout the day in a single field, those taken during the midday (11 a.m. to 1 p.m.) yielded approximately four times as many midges as sweeps made in the early morning (8 to 9) or late afternoon (4 to 5). Therefore, light infestations are most likely to show up if the sweeps are taken during the midday period.

The most reliable method of detecting Ladino clover seed midge infestations is to find the larvae in the clover heads. By picking heads in which one-third to three-fourths of the florets have turned down and are becoming brown, one can be assured that any mature larvae present will begin dropping out in a day or two. If the heads are placed in transparent cellophane bags, they can be kept fresh for several days; when the orange-colored larvae emerge, they can be seen through the bags. It is best to leave several inches of stem on the heads. Then, if the heads are placed in the bags stems down, the emerging larvae will fall free of the heads to the bottom of the bags. Otherwise, in their attempt to hide, the larvae may crawl back into the heads to spin their cocoons and not be detected. If the clover heads are to be taken to the laboratory, the bags are handy for keeping them fresh in transit.

In the laboratory the clover stems are put in bottles of water, with the heads leaning free of the bottle mouths. Bottles containing the clover are then set in pans into which the emerging larvae drop and accumulate. By this method the clover heads can be kept fresh enough at room temperature to obtain daily larval emergence counts for 10 to 12 consecutive days. The pans can be checked at any convenient time, even days after they are set up. This method will reveal infestations too light to be evident by any of the other methods discussed.

R. F. Smith [30], J. E. Swift [31], G. L. Smith [32], and W. W. Middlekauff [33]

Survey Methods Used in California

On alfalfa seed.--Alfalfa grown in California for seed is treated for lygus control only when the lygus bug population justifies treatment. The treatment level will vary with the growth stage of the alfalfa. The treatment levels are the numbers that indicate the proper time of insecticide applications and are not, necessarily, the population density at which economic damage occurs. Treatments are made at these levels to avoid later populations that may cause economic damage.

Lygus counts are based on two-sweep counts taken with a standard net at 10 to 20 stations over a field. At least three, two-sweep counts are made at each station. The margins of the field, spots with heavy growth, and other areas of the field may have a significantly higher count than the remainder of the field. In general, all counts in a field are averaged and treatment is based on this average population. Occasionally, it is practical to treat only parts of a field.

Alfalfa in the early bloom stage is treated when the lygus bug count reaches one insect per sweep. During the period of seed set, the fields are treated when the count of lygus bugs reaches six per sweep. Counts are determined by doubling the nymph count and adding it to the adult count. For example, two adults and two nymphs per sweep equal a count of six; four adults and one nymph also equal a count of six; and similarly, three nymphs or six adults equal a count of six. If lygus bugs have been kept under control during the period of seed set, there is seldom any need for treating the maturing field. However, if the pests appear to be unusually abundant, the count for treatment is 10 per sweep, determined in the same manner as described above.

On cotton [34].--Lygus bugs are particularly attracted to succulent or rank-growing cotton. Sweeps in cotton are made through the tops of one row. An average total of 10 lygus bugs per 50 such sweeps is the minimum injurious number. Each nymph is counted as two and each adult as one. The presence of nymphs indicates a more advanced and serious infestation. This is for average conditions. A lower population that is maintained for a long period of time may possibly cause economic damage. However, in most years the populations do not hold steadily at one level.

30/ Department of Entomology and Parasitology, University of California Berkeley, Calif.

31/ Agricultural Extension Service, University of California, Berkeley, Calif.

32/ Retired, formerly with University of California, Berkeley, Calif.

33/ College of Agricultural Science, University of California, Berkeley, Calif.

34/ See also Cotton Insects section on Lygus Bugs or Other Mirids, page 48.

On blackeye beans or cowpeas.--A favored oviposition site of lygus bugs infesting blackeye beans or cowpeas is in the developing pod. Such spots are commonly seen as small depressions with the cap of the egg forming the bottom. As the season progresses so does the number of nymphs. It is not unusual to find fields in which there are more nymphs than adults. In lygus-infested blackeye bean fields, it is possible to show a correlation between populations and the amount of injury at harvesttime. These fields are sampled by means of a standard 15-inch net. A sweep across two rows of beans constitutes one sweep, and five such sweeps are made at each of 10 stations in the field. The total number of adults and nymphs is recorded separately for each series of five sweeps. A population averaging 50 or more lygus bugs per sweep is sufficient to cause considerable damage, especially if lygus bugs are present when beans are in a susceptible stage. A population this heavy can be tolerated until late-bloom and early pod stage when the beans should be treated.

Studies have made possible the following generalities concerning abundance and resulting seed injury. A population averaging 0 to 10 lygus bugs per 50 sweeps persisting from early pod stage to harvesttime will result in from 0.4 to 2.0 percent of beans with injury. A population of from 15 to 20 will cause 2.5 to 5.0 percent seed injury, from 40 to 50 lygus bugs will cause 6.0 to 12.0 percent injury, and 60 lygus bugs or more per 50 sweeps will cause 15 percent or more of seed injury.

Spittlebugs

H. B. Petty [35]

Survey Methods in Illinois

With an increase in spittlebug infestations up to economic levels in Illinois, an attempt to predict the potential populations that might occur on legume crops in the spring was considered desirable. Based on biological data from Ohio and field experience in Illinois, a survey technique for this purpose was developed in Illinois for use in 1951 and 1952. On the basis of data obtained in an adult spittlebug survey in the fall, probable damage ratings were determined for the following spring.

In late August or early September after the adult spittlebug populations became fairly stable (determined by regular sampling of a few fields), 30 counties were surveyed in Illinois to determine adult populations. Ten fields were selected at random in each county. Ten individual sweeps (standard 15-inch net with 180° sweep) were made in each field and each recorded separately on a special form. (See following page). The condition of the field and other pertinent data were also recorded. Based on the average number of adult spittlebugs per sweep in each county, predictions were made for the areas most likely to be subjected to economic losses the following spring.

[35] Department of Entomology, University of Illinois, Urbana, Ill.

By assuming that for each adult spittlebug per sweep there likely would be one-fourth to one-half spittlebug nymph per stem the following spring (Ohio's results), estimates were made of the acreage of new stands worthy of treatment. Treatment was recommended on first-year hay crop fields in those areas where an average of one-half or more nymphs per stem was anticipated. As a followup in late May, nymph counts were made on a 100-stem sample in many of the fall-survey fields and observers found that for county averages the predicted and actual numbers of nymphs per 100 stems were substantially the same.

This survey method gives actual figures upon which to base and check predictions. By this method it is possible to obtain a quantitative cross section of populations in old and new fields and in fields of various mixtures of grasses and legumes, mixed legumes, and straight stands of legumes.

Spittlebug Survey

Fall. Date ________________. County ________________.
Crop ________________. Old. New.
Condition: Good. Fair. Poor. Height inches. Clipped. Unclipped.
Location: N. S. E. W. side of Rt. ______. __________ miles N. S. E. W.
of ________________.
__________ miles N. S. E. W. of ________________.
Adults per sweep: 1. _____. 2. _____. 3. _____. 4. _____. 5. _____ 6. _____.
7. _____ 8. _____ 9. _____. 10. _____. Average __________.
Spittlebug masses observed - Yes. No.

Spring. Date ________________.
Infestation per 10 stems: 1. a. _____ b. _____. 2. a. _____ b. _____. 3. a. _____
b. _____ 4. a. _____ b. _____. 5. a. _____ b. _____ 6. a. _____ b. _____.
7. a. _____ b. _____ 8. a. _____ b. _____ 9. a. _____ b. __________.
10. a. __________ b. __________. Total a. __________ b. __________.
a=Infested plants.
b=Number of nymphs.
Adults observed. Yes. No.

Notes: ________________

Sweetclover Weevil

G. R. Manglitz [36]

Adults of the sweetclover weevil (Sitona cylindricollis Fåhraeus) are quite difficult to detect, even when present in great numbers. Further, unless the time of day, character of day, and season of the year are considered, numbers collected by the sweep method are meaningless. Thus, the characteristic half-moon notches cut into the margins of the leaves are the best indication of damaging populations. When 50 percent of the foliage in new seedings is destroyed, controls are recommended. The weevil rarely destroys older, established stands.

Small Grains

Armyworm

W. J. Colberg [37] and V. V. Goodfellow [38]

Methods Used in North Dakota

Watch for armyworm (Pseudaletia unipuncta (Haworth)) infestations during wet seasons. Early infestations usually will be restricted to grassy areas and in lodged grain. When small, the larvae are usually curled up and on the ground. They feed during late afternoon, night, and early morning. Injury consists of leaf stripping and head clipping.

In surveying for armyworms, first check the field margins and lodged areas. If the pests are present, then move into the standing grain. Whenever larval counts reach three to four per linear foot or 6 to 8 per square foot in the field, insecticidal control is recommended. There are exceptions, however. If the crop is nearly mature and there is no evidence of head clipping, control is not advised. Also, if the larvae are all about 2 inches long, insecticidal control is not advised as most of these larvae are through feeding and they will pupate very shortly. At 50-pace intervals 10 to 20 counts will provide a good estimate of the infestation.

36/ Department of Entomology, University of Nebraska, Lincoln, Nebr.

37/ Department of Entomology, College of Agriculture, North Dakota State University of Agriculture and Applied Science, Fargo, N. Dak.

38/ Crop Quality Council, Minneapolis, Minn.

Barley Thrips

W. J. Colberg [39] and V. V. Goodfellow [40]

Methods Used in North Dakota

Look for adult barley thrips (*Limothrips denticornis* (Haliday)) within the terminal leaf sheath of barley when the plant is in the boot stage and before barley heads.

Control of barley thrips is advised when the adult population averages two or more per stem, when the heads are just beginning to emerge, and before the crop is fully headed. To obtain an accurate count, check several stems throughout the field. If numerous nymphs are present at the time of survey, control is probably too late to advise.

Chinch bug

C. W. Shockley [41]

Surveys to determine populations of hibernating chinch bug (*Blissus leucopterus* (Say)) are conducted during November and December in areas suspected of harboring infestations. Overwintering occurs in several species of bunch grasses, including little bluestem, big bluestem, and broomsedge. Five samples of bunch grass are collected at widely separated points in each county surveyed. Each sample consists of a bunch of grass, including the crown, from 3.5 to 4.5 inches in diameter that is cut from the sod clump with a tilling spade. After trimming, the sample is placed in a double paper bag on which the location, date, and other pertinent details are recorded. By examining samples of the grass clumps in the laboratory, hibernating bugs are detected and the abundance determined. As counts are made, the number of bugs in the sample is converted to a number per square foot and rated according to the following:

Classification	Number of bugs per square foot	Rating
Noneconomic	0 to 250	1
Light	250 to 500	2
Moderate	500 to 1,000	3
Severe	1,000 to 2,000	4
Very severe	2,000 or more	5

39/ Department of Entomology, College of Agriculture, North Dakota State University of Agriculture and Applied Science, Fargo, N. Dak.
40/ Crop Quality Council, Minneapolis, Minn.
41/ Plant Pest Control Division, ARS, USDA, Oakland, Calif.

A rating is assigned to each county based on stop ratings and percentage of land under cultivation in the county. The greater the percentage of cultivated land the less protective cover available for hibernation and, consequently, a reduced population in comparison to crops that may be attacked.

Information obtained from these surveys provides a basis for preliminary estimate of control needs and a record of hibernating populations. However, weather conditions the following spring determine the severity of infestations.

Grain Aphids

W. J. Colberg 42/ and V. V. Goodfellow 43/

Methods Used in North Dakota

Greenbug (*Schizaphis graminum* (Rondani)), English grain aphid (*Macrosiphum avenae* (Fabricius)), and corn leaf aphid (*Rhopalosiphum maidis* (Fitch)) are the principal species of grain aphids in North Dakota. Greenbug, definitely the most injurious species, seldom becomes economically important in North Dakota. English grain aphid starts building up on the leaves; later in the season this species moves into the heads of grain. Corn leaf aphid may build up quickly; however, the infestations are seldom economically important except possibly in extremely late-seeded crops.

In surveying for aphids, make several counts throughout the field. Too frequently, farmers become alarmed after checking a few plants along the margins where populations are high. Counts should be at least 50 paces apart, and observations should be made well into the center of the field. Start counts from at least two sides of the field.

A rating for the infestation is as follows:

Classification	Number of aphids per linear foot
Noneconomic	1 to 10
Light	11 to 50
Threatening	51 to 100
Severe	101 to 300
Very severe	Above 300

Insecticidal control is advised whenever the greenbug infestation approaches the category of light to threatening. For English grain aphid and corn leaf aphid, the infestation should approach the severe category before insecticidal control is recommended. When the English grain aphid moves into

42/ Department of Entomology, College of Agriculture, North Dakota State University of Agriculture and Applied Science, Fargo, N. Dak.

43/ Crop Quality Council, Minneapolis, Minn.

the heads of grain, several hundred heads of grain should be examined throughout the field. If the average infestation per head is 25 to 30 aphids, control is advised, especially if the crop is late and populations of predators and parasites are low.

Winged viviparous female, oviparous female and antenna of greenbug

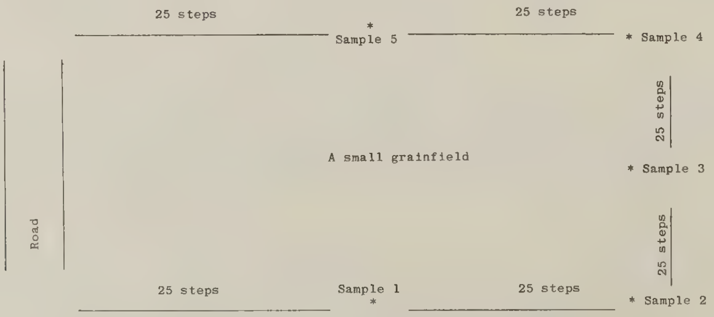
Greenbug

R. G. Dahms [44]

Survey Methods Used in Texas, New Mexico, Oklahoma, and Kansas

Two surveys for greenbug (Schizaphis graminum (Rondani)) are usually made each year--(1) in November to determine the fall infestation and (2) the latter part of February or early March to determine winter survival and the potential infestation present.

Where large, small grain acreages are present, at least five fields are examined in each county. Fields selected should be at least 5 miles and preferably not more than 15 miles apart. In the November survey, an effort is made to select early emerged fields or fields containing volunteer plants. The exact location of the field is recorded, together with any pertinent notes on crop status and development. Five samples are examined about midway along the edge of the field. Each sample area is 25 steps apart as illustrated below:



[44] Grain and Forage Research Branch, Entomology Research Division, ARS, USDA, Beltsville, Md.

Each sample consists of 1 linear foot of drill row. If the infestation is light (50 or less greenbugs per linear foot), an exact count is made. However, if the infestation is heavy, an estimate of the number per linear foot is made. If the heavy infestation appears to be uniform, the estimate is made by counting the number on one plant and multiplying it by the number of plants in the 1-foot sample. A numerical rating of 0 to 5 is given each sample as follows:

Rating	Classification	Number of greenbugs per linear foot
0	None	0
1	Noneconomic	1 to 10
2	Light	11 to 50
3	Threatening	51 to 100
4	Severe	101 to 300
5	Very severe	Above 300

The average numerical rating for the five samples is entered in the survey data report. The prevalence of parasites and predators is recorded in the remarks column of the survey data sheet.

Hessian Fly

R. L. Gallun [45]

Annual surveys to determine the distribution and population density of Hessian fly (*Mayetiola destructor* (Say)) races are conducted near harvesttime in winter wheatfields. One sample taken from a field consists of 100 or more stems collected at random from different parts of the field. The date collected, grower's name, location, and wheat variety are recorded for each sample. Since examinations are usually made at a field laboratory, the samples, when collected, should be placed in individual paper bags or tied with fine wire or string and stored in a cool, dry place. Samples from certified wheatfields are preferred, because these fields are distributed throughout the State and give a better representation of samples from a particular area. A county, an assembly of counties, or an area is rated on the average infestation recorded from the samples examined as follows:

Average percent of infestation	Infestation rating
7.5	Low
17.5	Moderate
27.5 or more	Heavy

45/ Department of Entomology, Purdue University, Lafayette, Ind.

Insects Found in Small Grain Fields

C. E. White [46], L. L. Peters [47], and O. H. Hammer [48]

The principal method used in small grain insect surveys is the linear foot of drill row in drilled grain or the square foot in broadcast grain fields. However, sweeps, head counts, stem counts, and leaf counts also can be used.

The Linear-Foot Method

Very carefully examine 1 linear foot of row at five different places in the field and count all insects found. Pull the trash away from the base of the plants to find certain larvae hiding in the trash or on the ground under the trash. Report the number of insects per 100 linear feet, except aphids and chinch bugs that are reported as the number per 1 linear foot. The linear-foot method is used for armyworms, cutworms, wireworms (by searching in soil), aphids, chinch bugs, mites, and predatory insects.

The Square-Foot Method

This method is the same as the linear-foot method except a square foot is used instead of a linear foot. Use only where grain is broadcast or badly lodged. Report per square foot.

The Sweep Method

Sweeps are made in the same manner as those described for clover, alfalfa, and grass insects. In grain this method can be used after grain reaches a height of 4 to 5 inches for aphids, very small armyworms, and predatory insects.

The Head Count Method

Count the insects on 10 to 25 heads selected at random. Report the number per 100 heads. The head count method is used for aphids, especially the English grain aphid, and in grain sorghum for lepidopterous larvae and sorghum midge.

The Leaf Count

Perhaps in extremely high populations of mites, aphids, or thrips determining the population by counting the number on 10 to 25 randomly selected leaves and reporting the number per 100 leaves may be more satisfactory than determining the number per linear foot.

46/ Department of Entomology, University of Illinois, Urbana, Ill.
47/ Department of Entomology, University of Missouri, Columbia, Mo.
48/ Dow Chemical Company, Bio-Products Center, Midland, Mich.

The Stem Count

Count all the insects or damage found on or in individual stems. Examine total of 10 to 100 stems. Examine under the leaf sheaths as well as other parts of the stem. Do not examine all the stems in one spot but examine a group of 2, 5, or 10 stems, then move to another spot at least 25 steps away and examine another group. This method is used for Hessian fly larvae and puparia, wheat stem sawfly, wheat stem maggot, and wheat jointworm. In the wheat jointworm, count "points" rather than worms. Report the number of insects per 100 stems and the percent of stems infested.

Rice Stink Bug

Glyn Odglen 49/, L. H. Rolston 50/, Grover C. Dowell 51/, and W. P. Boyer 52/

Survey Methods Used in Arkansas

The sweep net may be used to collect rice stink bug (*Oebalus pugnax* (Fabricius)) to determine numbers present and seasonal development. The development of this species within a ricefield is associated with the presence of barnyard grass (*Echinochloa crusgalli*) on which the bugs feed before heading of the rice. As the rice heads develop, dispersal of bugs to rice occurs; however, feeding may continue on barnyard grass. Because of this, the sweep net method has disadvantages as the growing season develops. One disadvantage is that the sweep net, which collects bugs from both the rice and the grass, may not give a true picture of the bug population actually feeding on rice. Another disadvantage is the surveyor's difficulty in walking through the tall plants and the flooded fields. Field coverage is difficult because some bugs fly ahead of the surveyor when they are disturbed.

The methods adopted in Arkansas are the use of 6 X 30 binoculars and "eyeballing." The surveyor walks the levees to obtain field coverage. At least 10 stops for observations are made in each field. At each stop the surveyor focuses the binoculars on 10 heads of rice located at sufficient distance so that the bugs have not been disturbed and counts the bugs seen. While looking at the same 10 heads, the surveyor moves a few steps to change the angle of observation, enabling him to see bugs that may have been hidden from view at the first stop. In the "eyeballing" method the same procedure is followed. To keep his vision on the same 10 heads of rice while counting, the surveyor holds out his hand and uses it as a focusing point. With this method bugs can be seen at a sufficient distance so that the surveyor will not disturb them from the vantage point on the levee; however, the use of binoculars is preferred. Counts are recorded in terms of bugs per 100 heads of rice.

49/ Formerly graduate student, Department of Entomology, University of Arkansas, Fayetteville. Current address: R.F.D. #2, Newport, Ark.
50/ Department of Entomology, Louisiana State University, Baton Rouge, La.
51/ Monsanto Company, St. Louis, Mo.
52/ Department of Entomology, University of Arkansas, Fayetteville, Ark.

Rice Weevil

W. A. Douglas 53/

A system for evaluating hybrids or varieties of corn for rice weevil (Sitophilus oryzae (Linneaus)) resistance or susceptibility has been worked out by a group of entomologists as given below.

Both percent of ears infested and the degree of infestation of those ears are considered, with the resulting figure representing percent kernel infestation for the hybrid or field.

Procedure in field:

- Separate infested ears from clean ears, based on weevil emergence holes and larval feeding signs; record total number of ears and number of infested ears.

- By gross examination, give pile of infested ears a grade according to degree of infestation.

Grade	Percent of kernels infested
1	1 to 5
2	5 to 15
3	15 to 40
4	40 to 70
5	70 to 100

- Take field samples of grain for moisture content and include with rice-weevil infestation data.

Procedure in office:

- Calculate percent of ears infested, each replicate; calculate average, all replications (column 1 in sample below).

- Calculate degree of infestation by averaging grades for hybrid, all replications (column 2 in sample).

- Using table 1, determine degree of infestation represented by average of grades (column 3 in sample).

- Multiply column 1 by column 3 in sample below to get percent of kernels infested for hybrid--final column 4.

53/ Grain and Forage Insects Research Branch, Entomology Research Division, ARS, USDA, State College, Miss.

Sample for calculating the degree of infestation:

Hybrid	Column 1 Average percent ears infested	Column 2 Average grade	Column 3 Percent of weevils in infested ears	Column 4 Final rating. Percent of infested kernels
D-18	20	2.2	13	2.6

19,18,26,22,14,21 - Av. = 20
2,3,3,1,2,2 - Av. = 2.2
2.2 in table = 13.0

20 x 13 = 2.6

Table 1. Data for determining degree of weevil infestation represented by average of grades:

Average of grade	Percent infestation infested ears	Average of grade	Percent infestation infested ears
0.1	0.5	2.6	19.0
0.2	0.5	2.7	21.0
0.3	1.0	2.8	23.0
0.4	1.0	2.9	25.0
0.5	1.1	3.0	28.0
0.6	1.3	3.1	30.0
0.7	1.5	3.2	32.0
0.8	1.8	3.3	35.0
0.9	2.1	3.4	37.0
1.0	2.5	3.5	40.0
1.1	3.0	3.6	43.0
1.2	3.5	3.7	46.0
1.3	4.0	3.8	49.0
1.4	4.7	3.9	52.0
1.5	5.3	4.0	55.0
1.6	6.0	4.1	58.0
1.7	6.7	4.2	61.0
1.8	7.6	4.3	64.0
1.9	8.7	4.4	67.0
2.0	10.0	4.5	70.0
2.1	11.0	4.6	73.0
2.2	13.0	4.7	76.0
2.3	14.0	4.8	79.0
2.4	16.0	4.9	82.0
2.5	17.0	5.0	85.0

Wheat Stem Sawfly

E. G. Davis [54]

Wheat stem sawfly (Cephus cinctus Norton) surveys are conducted at the conclusion of harvest in wheatfields in the northern Great Plains area. The survey is made of the overwintering larval population by examining two samples in each of 10 well-distributed fields in each county. One sample is taken near the margin of the field within the first few drill rows and the other, at approximately the center of the field. At each sample location, 50 consecutive wheat stems of a drill row are examined for stubs cut off by the sawfly. The total number of these sawfly stubs found in the two samples is recorded as the percentage of infestation for the field.

Upon completion of the survey, the fields are placed into one of four classifications based on their percentage of infestation as follows:

Classification	Percent of Stems Infested
Light	Trace to 5
Moderate	6 to 24
Heavy	25 to 39
Severe	40 to 100

A map of the infestation is prepared by locating each classified field on a map of the surveyed region and delimiting the areas of different population abundance. The information obtained from the survey provides a basis for determining the extent of the infestation, for making certain data available, and for assisting in an appraisal of the wheat loss caused by the sawfly.

Diversified Crops

Cutworms

W. J. Colberg [55] and V. V. Goodfellow [56]

Methods Used in North Dakota

Several species of cutworms infest crops. Many feed above ground, others feed below the soil surface. The need for control is based primarily upon crop injury because no easy method can determine economic infestations.

[54] Retired, formerly with Grain and Forage Insects Research Branch, Entomology Research Division, ARS, USDA.

[55] Department of Entomology, College of Agriculture, North Dakota State University of Agriculture and Applied Science, Fargo, N. Dak.

[56] Crop Quality Council, Minneapolis, Minn.

One survey method used for cutworms in North Dakota is to place several piles of straw, hay, and such in the area where cutworms are suspected. After a few days, lift the piles and check for the larvae. If several cutworms are found under each pile, the infestation would be considered threatening and control would be advisable.

This sampling method does not work for the species that feed underground. About the only method of checking on these would be to dig along the row and count the number of larvae per foot in the row. One or more cutworms per linear foot would be considered serious.

Grasshoppers

Plant Pest Control Division
Agricultural Research Service

Adult Survey

Soon after grasshoppers have dispersed from nymphal concentrations and have reached the adult stage all infested areas should be surveyed. This survey should be timed to coincide with peak populations, enabling completion of the survey before appreciable decline in grasshopper numbers occurs.

Known infestations and new infestations should be classified or mapped according to the table below. Eight or more grasshoppers per square yard are economic, seven or fewer noneconomic.

Rating table
grasshopper adult infestations

No. of adults per square yard			
Field 1/	Margin 2/	Rating	Suggested map color
0 to 2	5 to 10	1	White
3 to 7	11 to 20	2	Green
8 or more	21 and above	3	Red

1/ Field stop ratings are to be used for both rangeland and field crop stops.
2/ For obvious reasons, there will be no margin rating for rangeland stops.

Evaluation of Adult Populations

To obtain an estimate of the number of adult grasshoppers per square yard, a system of multiple estimates should be used. This involves a series of actual counts of grasshoppers as they leave a square foot, selected by the surveyor well ahead of his line of march. Eighteen counts should be made 15 to 20 paces apart through the range, field, or margin being sampled. At the completion of the count, the total number of grasshoppers from the 18 square feet should be computed. This total divided by two will convert this figure to the number of grasshoppers per square yard. It is advisable to occasionally lay off a square foot on the ground to keep the size of this unit area fixed in mind. The time of day, temperature, density, and height of vegetation all affect grasshopper activity and should be considered in making counts of grasshoppers.

Where hatching has been irregular and where populations of mixed species exist, nymphs may be present with adult grasshoppers. In making the adult survey, if the nymphs are in the fourth or fifth instars, they should be counted as adults. If the occurrence of large numbers of first- to third-instar nymphs of economic importance is encountered frequently in an area, delay in the survey until a later date is advisable. If a delay is impractical and this situation involves only an occasional stop, reduce the count of first- to third-instar nymphs to one-third before the figure in terms of adults is recorded on the record sheet.

In large field areas where fields consist of 80 acres or more and in range areas where the vegetation is uniform, only one habitat need be examined at each stop.

In diversified crop areas where fields are usually less than 40 acres, two or more fields should be sampled; or in range areas where several vegetative types exist, each of the habitats should be sampled. Populations in each crop and habitat should be determined. These populations should be averaged to determine a population for the stop. This average population of all fields or habitats sampled is used to rate the stop.

In all cases, the observer should walk sufficiently far into each field to insure that the count of grasshoppers represents an average value for the field examined. Likewise, on the margin, a sufficient length of the margin should be examined to insure an average count.

Population counts on the margin should also represent an average value for the entire width, from the edge of the road to the edge of the field. Most margins will be 2 or more rods wide, and for all such margins the population count should be recorded as an average for the entire width and the length examined. However, for narrow margins of less than 2 rods, the population count should be reduced proportionately. For example, the population count on a 1-rod margin would be reduced one-half. When there is no distinct vegetative difference between the field and the margin and there is no concentration of grasshoppers along the margin, the field count should be recorded for the stop. No separate margin count need be made. This would apply to some ungraded roads or to roads through crops. Do not use margin counts when evaluating range stops.

After the number of grasshoppers per square yard has been determined for any stop, a rating for that stop is recorded on a road map or county outline map by using the adult rating table. When marginal and field ratings differ, the higher rating should be assigned to the stop. The field counts are not to be combined with the marginal counts and averaged to obtain stop ratings.

The stops in the various crops and range should be well distributed and in approximate proportion to their relative county acreage.

The adult survey should be started in each State at the earliest possible time, determined by the maturity and behavior of the grasshoppers, and completed, where possible, within a period of 2 weeks. Actually the best survey is that which is the culmination of a whole season's observation of grasshopper development by the surveyor who had the opportunity to observe them in given areas.

From 25 to 50 stops should be made in each county, depending on the nature of the infestation, the supervisor's knowledge of the infestation, and the size of the county. Fewer survey stops are required in an area that is lightly and evenly infested than in an area that is heavily and irregularly infested. In small counties and in counties where the supervisor is familiar with the infestation, 25 stops usually will be adequate. Areas in which infestations are of doubtful degrees of intensity and areas that border known heavy infestations should be given more attention, and as many as 40 stops may be needed. Only in large counties or ones with extremely irregular infestations should it be necessary to make as many as 50 stops. To locate the boundaries of infestations more definitely, exploratory examinations, which need not be formally recorded, may be made in addition to the regular stops.

COTTON INSECTS

Cotton Council Data

Suggested methods for making uniform cotton-insect surveys were formulated at the Cotton Insect Research and Control Conference held in Memphis, Tenn., December 7-9, 1952. Revisions have been made in subsequent conferences. The following cotton-insect survey methods for boll weevil, bollworms, pink bollworm, cotton aphid, cotton fleahopper, cotton leafworm, lygus bugs or other mirids, spider mites, and thrips were approved at the Twenty-First Annual Conference on Cotton Insect Research and Control held January 9-10, 1968, in Hot Springs, Ark., and are published in the conference report (pp. 79-86) 1/.

1/ Copies available from Entomology Research Division, ARS, USDA, Plant Industry Station, Beltsville, Md. 20705

Survey records to determine winter survival of the boll weevil (Anthonomus grandis Boheman) are made in a number of States. Counts are made in fall soon after the weevils have entered hibernation and again in spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown during the previous season. Three samples are taken from each of 30 locations in an area usually consisting of three or four counties.

In the main boll weevil area, population counts are made on seedling cotton to determine the number of weevils entering cottonfields from hibernation quarters. The number per acre is figured by examining the plants on 50 feet of row in each of five representative locations in the field and multiplying the total by 50. Additional counts are desirable in large fields.

Square examinations are made weekly after the plants are squaring freely or have produced as many as three squares per plant. While you walk diagonally across the field, pick 100 squares, one-third grown or larger, taking an equal number from the top, middle, and lower branches. Do not pick squares from the ground or flared or dried-up squares that are hanging on the plant. The number of squares found to be punctured is the percentage of infestation. An alternative method is to inspect about 25 squares in each of several locations distributed over the field to obtain a total of 100 to 500 squares, the number depending upon the size of the field and the surrounding environment. The percentage of infestation is determined by counting the punctured squares. In both methods, all squares that have egg or feeding punctures should be counted as punctured squares.

The point sample method developed by Arkansas entomologists consists of the following procedures: Select a representative area in a field and mark a starting point on a row. Examine the first 50 green squares that are one-quarter inch or larger in diameter for boll weevil punctures. Count those that are punctured and step off the feet of row required for the 50 squares. Four such counts (a total of 200 squares) are adequate for uniform fields up to 40 acres in size. Fields that are larger or that are not uniform should be considered as separate fields with four counts made in each. The percentage of punctured squares, number of squares per acre, and number of punctured squares per acre can be determined from the point sample information.

A conversion table for usual row widths in an area with various numbers of row feet, 1 to 250, required for a 200-square count is prepared for ease in determining the number of squares and punctured squares per acre. Example: If 10 feet of a 40-inch row are required for 200 squares, there are 261,000 squares per acre. If 50 percent of the squares are punctured, there are 130,500 punctured squares per acre.

Bollworms

Examinations for bollworm (Heliothis spp.) eggs and larvae should be started as soon as the cotton begins to square and repeated every 5 days, if possible, until the crop has matured. In some areas it may be necessary to make examinations for bollworm damage before cotton begins to square. While you walk diagonally across the field, examine the top 3 or 4 inches of the main stem terminals, including the small squares, of 100 plants. Whole-plant examinations should be made to insure detection of activity not evident from terminal counts.

The point sample method developed by Arkansas entomologists consists of the following procedures: Select a representative area in a field and mark a starting point on a row. Examine the first 50 squares for bollworm damage. Count those that are damaged and step off the feet of row required for the 50 squares. Four such counts (a total of 200 squares) are adequate for uniform fields up to 40 acres in size. Fields that are larger or that are not uniform should be considered as separate fields with four counts made in each. The percentage of punctured squares, numbers of squares per acre, and number of damaged squares can be determined from the point sample information.

A conversion table for usual row widths in an area with various numbers of row feet, 1 to 250, required for a 200 square count is prepared for ease in determining the number of squares and damaged squares per acre. Example: If 20 feet of a 40-inch row are required for 200 squares, there are 131,000 squares per acre. If 10 percent of the squares are damaged, there are 13,100 damaged squares per acre.

Pink Bollworm

Counts to determine the degree of pink bollworm (Pectinophora gossypiella (Saunders)) infestation in individual fields may be made early in the season by inspecting blooms, and later by inspecting the bolls. Bloom inspections for comparing yearly early season populations, or for determining when early insecticide applications are needed, should be made so as to obtain an estimate of the number of larvae per acre.

Bloom Inspection

Five days after the first bloom appears, but not later than 15 days, check for number of larvae per acre as follows: Step off 300 feet of row (100 steps) and count the rosetted blooms at five representative locations in the field (1,500 feet). Add the number of rosetted blooms from these five locations and multiply by 10 to obtain the number of larvae per acre.

Boll Inspection

Check for the percentage of bolls infested as follows: Walk diagonally across the field and collect at random 100 firm bolls. Crack the bolls or cut each section of carpel (hull) lengthwise so that the locks can be removed. Examine the inside of the carpel for mines made by the young larvae when entering the boll. Record the number of bolls infested on a percentage basis.

Other Inspection Techniques

Other inspection methods are helpful in directing control activities against the pink bollworm. They make possible the detection of infestations in previously uninfested areas and the evaluation of increases or decreases as they occur in infested areas. They are also used to determine the population of larvae in hibernation and their carryover to infest the new cotton crop.

Inspection of gin trash.--Arrange with ginners to install traps where possible to procure freshly ginned "first cleaner" trash, which has not been passed through a fan, from as many gins as possible in the area. Maintain the identity of each sample and mechanically separate all portions of the trash larger and all portions lighter in weight than the pink bollworm. A small residue is left which must be examined by hand. This method is very efficient for detecting the presence and abundance of the pink bollworm in any given area. One may locate the exact field by catching a separate trash sample from cotton of each grower.

Inspection of lint cleaner.--During the ginning process, the free larvae remaining in the lint are separated in the lint cleaners, and a substantial number of them are thrown and struck on the glass inspection plates. All the larvae recovered are dead. For constant examination at a single gin, wipe off the plates and examine after each bale is ginned. In this way the individual field that is infested may be determined. For general survey, make periodic examinations to detect the presence of the pink bollworm in a general area.

Examination of debris.--Between January and the time squares begin to form in the new crop, examine old bolls or parts of bolls from the soil surface in known infested fields. Examine the cotton debris from 50 feet of row at five representative points in the field for number of living pink bollworms. Multiply by 50 to determine number of living larvae per acre. Such records when maintained from year to year provide comparative data that may be used in determining appropriate control measures.

Use of light traps.--Especially designed traps containing argon, mercury-vapor, or blacklight fluorescent bulbs will attract pink bollworm moths. Such traps are being used to discover new infestations, and their usefulness for survey work should be fully explored. Such traps are recognized as being an important means of survey for this pest as new infestations have been located through this use.

Use of sex-lure traps.--Traps containing a sex attractant extracted from the tips of abdomens of female pink bollworm moths have been highly effective in trapping male moths. Such traps are being used in surveys for detecting the insect in noninfested areas such as Arizona, California, and Nevada.

Cotton Aphid

To determine early season cotton aphid (*Aphis gossypii* Glover) infestations, you walk diagonally across the field, observe many plants, and record the degree of infestation as follows:

None------if none is observed.
Light-----if aphids are found on an occasional plant.
Medium----if aphids are present on numerous plants and some of the leaves curl along the edges.
Heavy-----if aphids are numerous on most of the plants and the leaves show considerable crinkling and curling.

To determine infestations on fruiting cotton, you begin at the margin of the field and, while walking diagonally across it, examine 100 leaves successively from near the bottom, the middle, and the top of the plants. According to the average number of aphids estimated per leaf, record the degree of infestation as follows:

None------0
Light-----1 to 10
Medium----11 to 25
Heavy-----over 26

Cotton Fleahopper

Weekly inspections for the cotton fleahopper (*Psallus seriatus* (Reuter)) should begin as soon as the cotton is old enough to produce squares. In some areas inspections should be continued until the crop is set. While you walk diagonally across the field, examine 3 or 4 inches at the top of the main-stem terminal of 100 cotton plants counting both adults and nymphs.

Cotton Leafworm

The following levels of cotton leafworm (*Alabama argillacea* (Hübner)) infestation, on the basis of ragging and the number of larvae per plant, are suggested for determining damage:

None-------if no leafworms are observed.
Light------if one or only a few larvae are observed.
Medium-----if two to three leaves are partly destroyed by ragging, with two to five larvae per plant.
Heavy------if ragging of leaves is extensive with six or more larvae per plant, or if defoliation is complete.

Lygus Bugs or Other Mirids [57]

Inspections for lygus bugs or other mirids should be made at 5- to 7-day intervals beginning at square set and continuing until early September. Infestations should be determined by making a 50- to 100-sweep count at each of four or more locations. Sweeping is accomplished by passing a 15-inch net through the tops of the plants in one row, the lower edge of the net slightly preceding the upper edge. Contents of the net should be examined carefully to avoid overlooking very small nymphs. The plant terminal inspection as described for the cotton fleahopper may also be used. During hot summer weather, sweeping should not be made between 11:30 a.m. and 3:00 p.m. since lygus bugs are prone to move into plant cover to avoid heat.

Spider Mites

For spider mites examine 25 or more leaves from representative areas within a field taken successively from near the bottom, the middle, and the top of the plants. According to the average number of mites per leaf, record the degree of infestation as follows:

None--------0
Light-------1 to 10
Medium------11 to 25
Heavy-------over 26

Thrips

While you walk diagonally across the field, observe or inspect the plants for thrips, and record the damage as follows:

None--------if no thrips or damage is found.
Light-------if newest unfolding leaves show only a slight brownish tinge along the edges with no silvering of the undersides of these or older leaves, and only an occasional thrips is seen.
Medium------if newest leaves show considerable browning along the edges and some silvering on the underside of most leaves, and thrips are found readily.
Heavy-------if silvering of leaves is readily noticeable, terminal buds show injury, general appearance of plants is ragged and deformed, and thrips are numerous.

57/ See also paragraph on lygus bugs on cotton in California in Cereal and Forage Section, Forage Legumes, page 28.

Survey Methods for Predators in Cotton in Arkansas

W. P. Boyer [58]

A survey method for predators in cotton that does not require added time while scouting for economic pests has been developed and is being used in Arkansas.

The method of survey adopted in Arkansas and used extensively in 1963 and 1964 is based on Lincoln's [59] earlier work. Predators scouted for are big-eyed bugs (*Geocoris* spp.), an insidious flower bug (*Orius insidiosus*), nabids (*Nabis* spp.), lady beetles (all species); and lacewing larvae (*Chrysopa* spp.). Lady beetle adults and larvae are recorded separately. Counts of nymphs and adults of the hemipterous predators are combined when recorded.

The survey procedure is as follows:

1. Record the number of predators seen on and in the 200 squares while making the 200-square point sample count.

2. Record the number of predators seen in terminals (top 6 inches) and on 100 leaves while making the standard 100-terminal count and the standard 100-leaf count. In Arkansas, the 100 terminals and leaves are selected by examining 25 terminals and leaves at random following each of the 50-square samples taken in point sampling.

3. Add the numbers of predators observed in procedures 1 and 2.

To further test this method against whole plant examination, six cotton insect scouts made both counts weekly in one field each for a period of several weeks in 1963. A total of 69 counts by each method was made. In making the whole-plant counts 100 plants per field were examined by selecting 25 consecutive plants at each of four locations (see data on following page).

58/ Department of Entomology, University of Arkansas, Fayetteville, Ark.
59/ Lincoln, C. Predators on cotton. U.S. Dept. Agr. Econ. Insect Rpt. 5(48): 1077-1078. 1955.

Total specimens 1/

	BEB	IFB	NAB	LBA	LBL	LWL	Grand total
Squares------------------	37	34	4	119	22	17	233
Terminals and leaves-----	38	50	6	87	11	15	207
Total--------------------	75	84	10	206	33	32	440
Whole plants-------------	120	152	20	290	53	69	704
Fast count expressed as percentage of whole-plant count--------	62.5	55.3	50	71	62.3	46.3	62.5

1/ BEB, big-eyed bugs; IFB, an insidious flower bug; NAB, nabids; LBA, lady beetle adults; LBL, lady beetle larvae; and LWL, lacewing larvae.

These data show that the fast-counting method accounts for 62.5 percent as many predators as does whole plant examination.

The counting period covered several weeks with counts being made before and after insecticidal applications.

Predator populations may be adequately estimated by counting those seen while examining squares, terminals, and leaves by the point-sample method of scouting. When special counts for predators only are made, examination of whole plants is more efficient.

Thrips in Cotton in Arkansas

Charles Lincoln, Gordon Barnes, and W. P. Boyer 60/

Winged migrant thrips, black or tan, may invade cotton in Arkansas anytime after the cotton emerges to a stand. After a week or so the wingless, straw-colored larvae become numerous unless the infestation is controlled by rain.

Begin scouting for thrips when cotyledons (seed leaves) have spread flat. Continue checking until the first two true leaves are full spread, which takes about 2 weeks in warm weather and about 3 weeks in cool weather. After cotton has two fully expanded true leaves, thrips have little effect on cotton plants in Arkansas.

Scout by slapping hills of cotton against a beater-box (fig. 1). On 20 plants the counts are as follows:

0 to 20 thrips none.
20 to 50 thrips light.
50 to 100 thrips medium.
over 100 thrips heavy.

60/ Department of Entomology, University of Arkansas, Fayetteville, Ark.

Control recommendations in Arkansas are made on the basis of this survey method and the above classification.

After cotyledons have fully spread for 1 week or longer, apply insecticides for heavy infestations. Before cotyledons have fully spread, light or medium infestations of adults show the potential for a heavy infestation. If no rain is forecast, it may be advisable to apply insecticides for a light infestation of adults during the cotyledon stage.

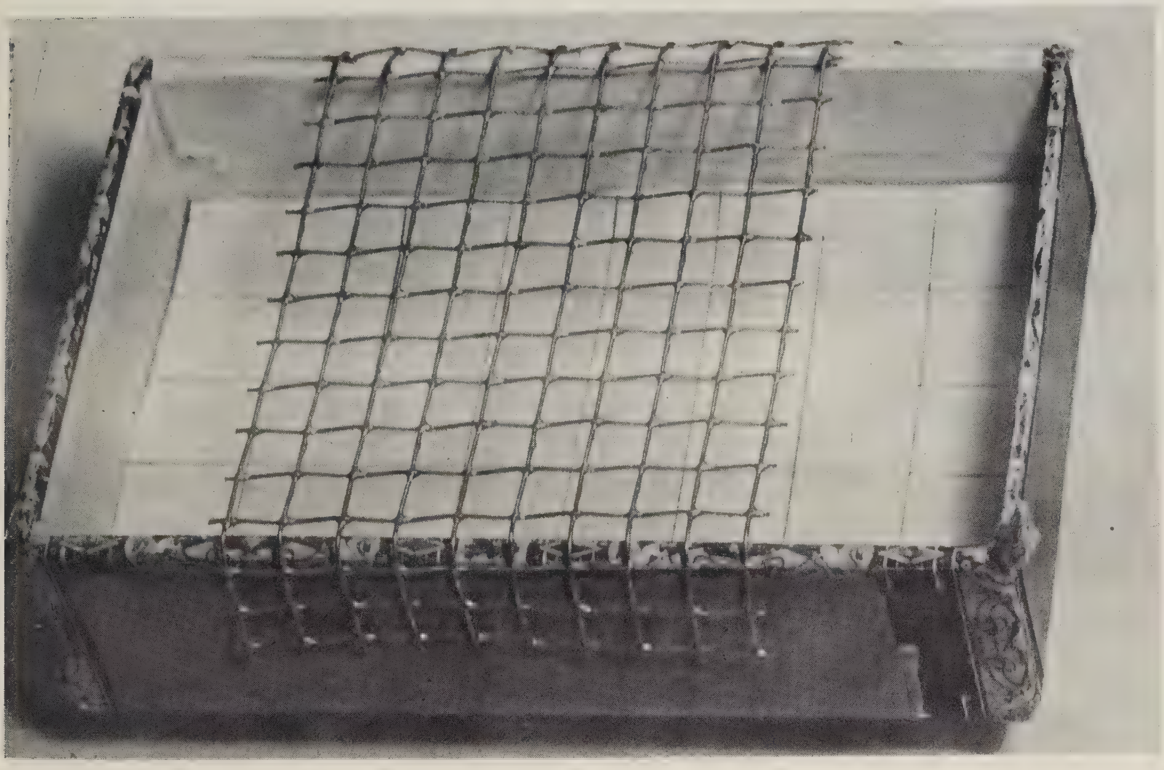


Figure 1.--Beater-box.

FOREST INSECTS [61]

Balsam Gall Midge Damage Appraisal Survey in the Lake States Region

R. L. Giese [62] and D. M. Benjamin [63]

Figure 1.--Needles damaged by the balsam gall midge.

The balsam gall midge (*Dasineura balsamicola* (Lintner)) seriously damages fir by stimulating proliferation of the needles and causes the formation of needle galls (fig. 1). The galls are ovoid, about one-eighth inch long and normally occur singly on the needle although up to five galls may form on one needle.

Galled needles and subsequent defoliation are employed in the appraisal survey. Of primary interest is the severity of infestation and secondarily, the past history of its presence.

Survey Procedures

Time of survey.--The survey may be conducted any time after June and before November.

Stand requirements.--The survey is restricted to balsam and Fraser fir trees between 5 and 20 feet in height, open growing stands in the lowland habitat and plantations and top cut-managed stands in any habitat.

Sampling Procedure

Five plots of four trees each are examined for each 40 acres. Smaller areas require one plot per each 5 acres. Plots are distributed uniformly throughout the stand. The quarter method automatically selects the trees. At any given station, the observer visually "quarters" the area; that is, front left, front right, rear right, and rear left. The closest tree in each imaginary quarter is sampled. On the whorl in the upper one third of the crown, select four branches representing the cardinal directions. For each branch, examine 10 apical current twigs and record the number of these that are infested. This requires a numerical value (rather than a check) to be entered on the tally sheet. On the same branches, estimate the damage level of ten 2-year-old and ten 3-year-old internodes (the 2-year-old internode immediately follows the current terminal twig and the 3-year-old internode is immediately

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[61] Papers in this section are essentially adapted from those originally sent to Plant Pest Control Division by the authors.

[62] Department of Entomology, Purdue University, Lafayette, Ind.
[63] Department of Entomology, University of Wisconsin, Madison, Wis.

behind the 2-year-old internode). About 1 percent of the galled needles remain on the trees indefinitely; any other galled needles will be represented by abscission scars. Numerous abscission scars reveal a heavy infestation 1 or 2 years ago. The actual estimate of previous damage is arbitrarily made by the observer, then entered on the tally sheet. (This part of the survey is optional and depends, in part, upon stand conditions and general vigor of the trees. In a very few instances, densely shaded, poor-vigor trees drop the needles after 1 year as opposed to the normal 4-10. In such cases, previous damage levels will be impossible to detect.)

Evaluation

The number of galled and nongalled twigs on current wood for the stand are totalled and the percent of twigs galled determined.

$$\frac{\text{Total twigs infested}}{\text{Total twigs sampled}} \times 100 = \text{percent twigs infested.}$$

The damage level is then derived from the damage level tables.

Damage Level Tables

A. Current growth -

Percent current twigs infested	Damage level
1 - 5	Light
6 - 40	Moderate
41 - 100	Heavy

B. Previous growth (2- and 3-year internodes only) -

Description	Damage level
Nearly all of old needles present, several scars, 1 or no galls remaining	Light
Between 10 and 50 percent of needles absent, several galls remaining	Moderate
Over 50 percent of needles absent, abscission scars abundant, several galls remaining	Heavy

If currently heavy, the survey (only the current twig part) is repeated the following year. If light, 3 years may elapse before another survey is needed.

The previous growth observations are summarized with the current growth data on the summary evaluation sheet. These data enable the observer to predict the rise and decline of populations under normal conditions and detect severe damage. Extreme heavily infested pockets are occasionally encountered. The locations of these are noted and observed at annual intervals; since these pockets may serve as infestation loci, future cutting when midge populations are low should be considered.

BALSAM GALL MIDGE APPRAISAL SURVEY SUMMARY AND EVALUATION

Stand number ______ Date ______________

County ___________ T ____ R ____ S ____ Forty ____ Observer ___________

Number acres _________ Number of plots ____________

Percent current twigs infested ______________________
Damage level current twigs Light _______ Medium _______ Heavy _______
Damage level of 2-year-old internodes Light _____ Medium _____ Heavy _____
Damage level of 3-year-old internodes Light _____ Medium _____ Heavy _____

Population trend ____

Survey to be conducted again ____

Marketing recommendations

BALSAM GALL MIDGE APPRAISAL SURVEY

Stand No. ______ Starting Point and Course ______ Date ______
County ______ T ______ R ______ S ______ Forty ______ Observer ______
Stand Composition ______

		Current Twigs Infested Per Ten Sampled				Damage Level Old Growth Indicate L. M. or H. Two year old Internode				Three year old Internode			
Plot	Tree	1	2	3	4	1	2	3	4	1	2	3	4
1	Branch 1 :												
	2 :												
	3 :												
	4 :												

Plot	Tree	1	2	3	4	1	2	3	4	1	2	3	4
2	Branch 1 :												
	2 :												
	3 :												
	4 :												

Plot	Tree	1	2	3	4	1	2	3	4	1	2	3	4
3	Branch 1 :												
	2 :												
	3 :												
	4 :												

Plot	Tree	1	2	3	4	1	2	3	4	1	2	3	4
4	Branch 1 :												
	2 :												
	3 :												
	4 :												

Plot	Tree	1	2	3	4	1	2	3	4	1	2	3	4
5	Branch 1 :												
	2 :												
	3 :												
	4 :												

Trend Check One L.__ M.__ H.__ | Trend Check One L.__ M.__ H.__

Larch Sawfly Damage Appraisal Survey in the Lake States Region

L. C. Beckwith [64]

The larch sawfly (Pristiphora erichsonii (Hartig)) is found throughout the tamarack type in the Lake States Region. However, the intensity of infestation varies from place to place. A standard method of appraising the damage is needed so that all agencies can report infestations in a similar manner. The following procedure, in use by the Division of Forest Insect Research, Lake States Forest Experiment Station, is submitted as a means of fulfilling this objective. It can be used once to obtain data on stand condition and severity of defoliation or annually to follow population trends.

Survey Procedures

It will be possible to follow population trends and to determine the factors causing, or leading up to, tree decadence by establishing permanent observation points throughout the tamarack areas.

Observation Point Establishment

All permanent observation points will be established in easily accessible tamarack stands, pole size or larger, that contain 70 percent or more tamarack and are at least 10 acres in extent. The landowner should be consulted to obtain permission to enter and to request that the stand will not be removed for a period of years. It would be advisable to locate points on public lands away from major highways whenever possible.

Each permanent observation point should be specifically located and described on the larch sawfly damage appraisal survey form so that it can be readily found. This form is shown on the following page. To facilitate ease of locating, each observation point should be adequately marked by a band of paint on a power or telephone pole or on nearby trees.

A line of 10 dominant trees, at least one chain apart beginning two chains in from the road, will be permanently marked and used for sample trees. Each tree should be marked with a 2-inch band of paint at breast height (bh = 4.5 feet above average ground level), completely circling the tree. A number (1 to 10) will be neatly painted above this band. A Valspar-type enamel, tangerine in color, has proved very satisfactory because it shows up well in the woods and has long-lasting qualities. Repainting is necessary when the numbers cannot be determined, or in case sample tree is windthrown and must be replaced by a nearby tree of similar size.

A square 1/10-acre plot (one chain on a side) will be established in the stand somewhere near the line of sample trees possibly containing some of them. A line of trees, immediately adjacent to the edge of this plot, will be painted to delineate the plot boundaries; the paint marks should face the center of the plot. The primary purpose of the plot will be to observe the development of tree decadence.

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[64] U.S. Forest Service, College, Alaska.

LARCH SAWFLY DAMAGE APPRAISAL SURVEY

(1) Collecting point No. ______ (2) Approx. acreage sampled ____ (3) Date ____

(4) Location: T____ R_____ S __________ (5) Landowner ____________________

(6) Reporting agency _______________ (7) Observers ____________________

(8) Stand condition:

Density:	Poor	Medium	Good
Site :	Dry	Hummocky	Wet

(9) Individual tree record

Tree No.	DBH	Ht.	Defoliation percent
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average			

(10) 1/10-acre plot

		Tamarack	Spruce	Cedar
No. living trees above 4" DBH class	______	______	______	______

(11) Remarks: ____

Instructions for Reporting Larch Sawfly Conditions

(1) For Reporting Agency only.
(2) - (7) - Self-explanatory.
(8) Underline one that best pertains to the stand.
Density: Forest Service Classification - Poor (100-224 trees/acre), Medium (225-324 trees/acre), Good (325+ trees/acre).
Site : Dry and wet are self-explanatory; hummocky refers to a stand that has very irregular ground surface, the high areas are generally dry while the depressions are generally wet.
(9) Tree record: Tree No., DBH (in tenths of an inch), Ht. (in feet), Defoliation percent (ocular estimate to the nearest 5 percent).
(10) 1/10-acre plot (1 ch. square).
(11) Any additional information concerning the stand condition.
(RETURN TO STATE AGENCY IN CHARGE OF SURVEY.)

Field Observations

At each observation point, a defoliation record will be marked on the survey form. Observations will be made after all feeding by the sawfly has ceased (approximately August 1).

Defoliation estimates.--A defoliation estimate will be made for each of the 10 marked sample trees. The live crown is visually separated into thirds, and an estimate to the nearest 5 percent is made for each crown level. Then an average for the tree is obtained. When averaging, it must be realized that the upper one-third of the crown does not represent one-third of the total foliage. In making the estimates, because defoliation may vary in different quadrants of the crown, it is necessary to walk completely around the tree. Defoliation estimates will be recorded separately for each tree; the plot average will then be based on these 10 trees.

The diameter at breast height (d.b.h.) for each of the 10 marked sample trees will be measured with a diameter tape to the nearest tenth of an inch and recorded on the form.

Total tree height for each sample tree is measured by using an Abney level or hypsometer and recorded.

One-tenth-acre plot observations.--Within the 1/10-acre plot all living trees in a 4-inch d.b.h. class or above will be counted and recorded by species. Only tamarack, spruce, and cedar should be considered.

By following these 1/10-acre plots over a period of years, some idea of tree decadence will be obtained. The recording of spruce and cedar as well as the tamarack should make possible the detection of tree decadence resulting from other factors besides the sawfly. An example would be excessive high water over a relatively long period. This should be reflected in all three tree species even though it may affect each in a different degree.

Red-pine Sawfly Survey Procedure for the Lake States Region

Joseph E. Kapler [65] and Daniel M. Benjamin [66]

The red-pine sawfly (*Neodiprion nanulus nanulus* Schedl) is an important defoliator of red pine (Norway pine) in eastern North America. Defoliation occurs in spring and is restricted to needles of the previous seasons even though currently developing foliage is present. Marked reduction in growth may occur after a single season's attack. Prolonged outbreaks resulting in the loss of all old foliage for three successive seasons may cause tree mortality.

65/ Loras College, Dubuque, Iowa.
66/ Department of Entomology, University of Wisconsin, Madison, Wis.

Evaluation of red-pine sawfly populations is best conducted during the egg stage after oviposition is completed in late fall. Eggs of this species remain on the tree until they hatch the following year in early May. Eggs are readily observed and little or no mortality occurs to interfere with the close relationship between egg numbers and subsequent defoliation. The other life stages all possess characteristics that preclude their utilization as valid and reliable population density criteria.

Red-pine sawfly eggs are inserted into the round face of current season needles near the tips of well exposed branches (fig. 1). They appear as a series of irregularly spaced, pale yellow, oval-shaped spots averaging eight per needle, with five to 13 eggs being commonly encountered (fig. 2). Each female lays approximately 50 eggs, concentrating them on several adjacent needles.

Sampling procedures are based on temporary plots located at random in red pine stands. The number of plots per 40 acres has been established at 10. In smaller areas one plot per 2 acres will suffice; in larger areas (100 acres or more), 20 plots will be employed. Time and availability of personnel will temper the intensity of the survey.

The size of the red pines to be examined and stand density will influence the precise procedure employed on each plot. Consequently, it is desirable to establish the program for each of the three major forest classes generally infested.

Figure 1. Red-pine sawfly female ovipositing in red pine needles.

Figure 2. Red pine needles containing eggs of red-pine sawfly.

Plantations Under 15 Feet in Height

In plantations under 15 feet in height, each sample plot will consist of 10 trees selected at random. For the presence of sawfly eggs, five twigs, one each from five different branches having current foliage (that is, needles that were grown during the recent season) will be examined per tree at breast height (b.h. = 4.5 feet above average ground level). Thus, at each station a total of 50 current twigs will be examined. The number of current twigs bearing sawfly eggs will be recorded on the survey sheet shown below and the data processed to yield an average number of egg-infested twigs per plot per plantation. Infestation classification will be determined by employing the following standards:

Average number of egg-bearing twigs per plot	Infestation classification	Predicted defoliation (percent of old foliage)
0 to 9	Light	0 to 25
10 to 19	Medium	25 to 50
Over 20	Heavy	50 to 100

Open Stands and Plantations (15 Feet in Height and Over)

In open growing red-pine stands 15 feet in height and over, 10 trees selected at random will constitute the sample. Because red pine is able to withstand complete defoliation for at least two seasons, twig examinations will be made only on plots showing evidence of red-pine sawfly defoliation occurring during the past season. This defoliation is recognized by presence of current foliage on branches that do not possess older foliage. Absence of defoliation will be recorded on the survey sheet by placing an "X" in the last column.

When sawfly defoliation is encountered, twig examinations will be made. Because of the height of the trees in these stands, a pole pruner is necessary to collect specimens. Branches will be cut from the upper crown of each sample tree, attempting to select 4-year-old branches wherever possible. Five twigs having current foliage will be examined for sawfly eggs on each tree. Results of the examination will be recorded on the tally sheet and the data processed to yield a stand classification. Plots on which no defoliation was observed, and consequently recorded as "X" on the summary column, will be included and considered noninfested in determining stand classification.

Closed Stands and Plantations (15 Feet in Height and Over)

In closed red-pine stands and plantations 15 feet and over in height, five trees selected at random will constitute the sample plot. As in the open stands of this height, twig examination will be made only on plots showing evidence of red-pine sawfly defoliation during the past season. Plots on which no defoliation is encountered will be recorded by placing an "X" in the last column on the tally sheet.

When sawfly defoliation is encountered, twig examination will be made. Collection of twigs by pole pruner generally is not practical because of the height of the trees and the closed canopy. An extension ladder, admittedly cumbersome to use in the forest, may be required to collect twig samples from 4-year-old branches in the upper crown. Ten current twigs will be examined per tree and the data recorded and processed to yield a stand classification.

Red-Pine Survey Procedure

Forest ____________ Ranger District ________ Plantation No. ________
Location T. ________ R. ________ Sec. ________ Quarter ________
Acreage ________ Average Ht. ______ Natural ____ Plantation ____ Open ____ Closed ____
Date ____________ Observer ____________

Plot No.	Number of Current Twigs bearing Eggs										Total Twigs bearing Sawfly Eggs
	1	2	3	4	5	6	7	8	9	10	

Total Egg Bearing Twigs ________
Av. No. " " " ________
Stand Classification ________

Saratoga Spittlebug Nymphal Appraisal Survey in the Lake States Region

H. G. Ewan [67]

Surveys on nymphal populations of the Saratoga spittlebug (Aphrophora saratogensis (Fitch)) are conducted to determine needs for insecticidal control measures. Such surveys will ordinarily begin about June 15 in northern Wisconsin and Michigan, although weather conditions may necessitate setting the date as much as a week earlier or later. In any case, the starting date of the survey will be when most of the nymphs are in the later instars and the ending date before transformation to the adult stage begins.

Survey Procedures

Sample Size.--Twenty sample plots shall be established per 100 acres of plantation. The individual plot encompasses an area of one-tenth milacre delimited by a portable square wooden frame (25 inches on a side, inside dimension). All plantations less than 50 acres will have 10 plots.

Plot Location

The plots must be evenly distributed according to lines predetermined on a plantation map. No plot should fall less than two chains from the edge of a plantation or a transecting road. The examiner will pace off the required distances and drop the plot frame immediately in front of him in an unbiased manner. The frame must not be moved from this point unless one or more of the following conditions are encountered:

1. No trees within 3 feet of the plot.--Always locate the plot frame so that it lies within 3 feet of the crown of a tree.

2. No ground cover.--If the trees have shaded out the low-growing plants, move the frame to a more open area. If no suitable spot can be found within one chain of the predetermined sample station, record this fact on the field form and move on to the next station.

3. Trees over 15 feet or less than 2 feet in height.--If either of these conditions prevails, record the fact and move to the next station.

Alternate Host and Nymphal Count

At each sample station, each individual host plant and each nymph within the confines of the frame are recorded on a field form shown on page 65. To detect nymphs, carefully press away the ground litter from the root-collar of the plant and look for the characteristic spittle mass. If a mass is observed, pull it apart and count the nymphs. If as many as 10 nymphs are found in any one plot, it is not necessary to count further but record this fact and move

[67] Deceased, formerly with Forest Service, USDA.

on. Any additional alternate host conditions observed by the examiner will be helpful in interpreting the data. For instance, if the "Others" column on the field form represents mainly hawkweed or bracken fern, a note should be made concerning its abundance.

Tree Size and Density

The average height of the trees, estimated to the nearest foot, and the average number of trees per acre must be recorded. The number of branch whorls on a representative (average sized) tree and any abnormal appearance of the trees, such as deformation and flagging, should be recorded.

The following points detail the use of the damage prediction table (shown at end of article following field form).

1. From the nymphal survey field form, the average number of tree units in the plantation is determined by obtaining the product of the average tree height (in feet), the average number of living branch whorls, and the average number of stems per acre. These three factors are determined by the observer in the field.

2. On the damage prediction table, the number of tree units is located in the column on the left and a straightedge placed across the table at this level.

3. From the nymphal survey field form, the total number of nymphs present in the first 1/10-milacre plot is determined.

4. This number is located in the top row of the damage prediction table and read downward to the point of intersection with the straightedge. The infestation level on the 1/10-milacre plot is then designated heavy, medium, or light, according to the infestation zone indicated by the table.

5. The infestation levels of all the remaining plots are determined by examining the field forms and going through the steps described above.

6. If 30 percent or more of the plots fall in the heavy infestation zone, the plantation is slated for immediate control.

The infestation level in a particular plantation may not be high enough to warrant immediate control, but it may be high enough to anticipate the need for control the following year. For instance, if 20 percent of the sample plots were found to be heavily infested and an additional 10 percent moderately infested, it is only logical to assume that after the insect has gone through the propagative stage, the population will have increased enough to constitute a heavy infestation. Therefore, a plantation may be designated as requiring a nymphal survey and possible control the following year if 30 percent or more of the sample plots are moderately infested. In this manner both the operational and appraisal aspects of spittlebug surveys may be logically and effectively combined in a single spring nymphal survey.

Infestation classification

The following empirical classification of tree damage on the basis of the feeding scar density on the xylem of the 2-year-old internodes has been established:

Feeding scars per 10 cm.	Tree damage level
0 to 10	Light
10 to 30	Medium
Over 30	Heavy

To classify an infestation on the basis of the spring nymphal population, the damage potential can be predicted according to the following relationship:

$$X = K\frac{A}{B}$$

X = number of feeding scars per 10 cm. of twig to be expected from the resulting adult population.

A = number of nymphs per one-tenth milacre.

B = number of tree units per acre = (number of trees per acre) x (average height of trees in feet) x (average number of living branch whorls per tree).

K = 17 (dimensionless constant).

ALTERNATE HOST AND NYMPHAL SURVEY FOR SARATOGA SPITTLEBUG

FIELD FORM*

National Forest______________ Ranger District ________________ Plantation Code No. ____________

Location: T. ____________ R. ____________ Sec. ____________ Acreage________________

Date________________________ Observer________________________

Sample number	Number nymphs per stem	Number Alternate Host Stems			Sample number	Number nymphs per stem	Number Alternate Host Stems		
		Sweet-fern	Rubus spp.	Others			Sweet-fern	Rubus spp.	Others
	0					0			
	1					1			
	2					2			
1	3				6	3			
	4					4			
	0					0			
	1					1			
	2					2			
2	3				7	3			
	4					4			
	0					0			
	1					1			
	2					2			
3	3				8	3			
	4					4			
	0					0			
	1					1			
	2					2			
4	3				9	3			
	4					4			
	0					0			
	1					1			
	2					2			
5	3				10	3			
	4					4			

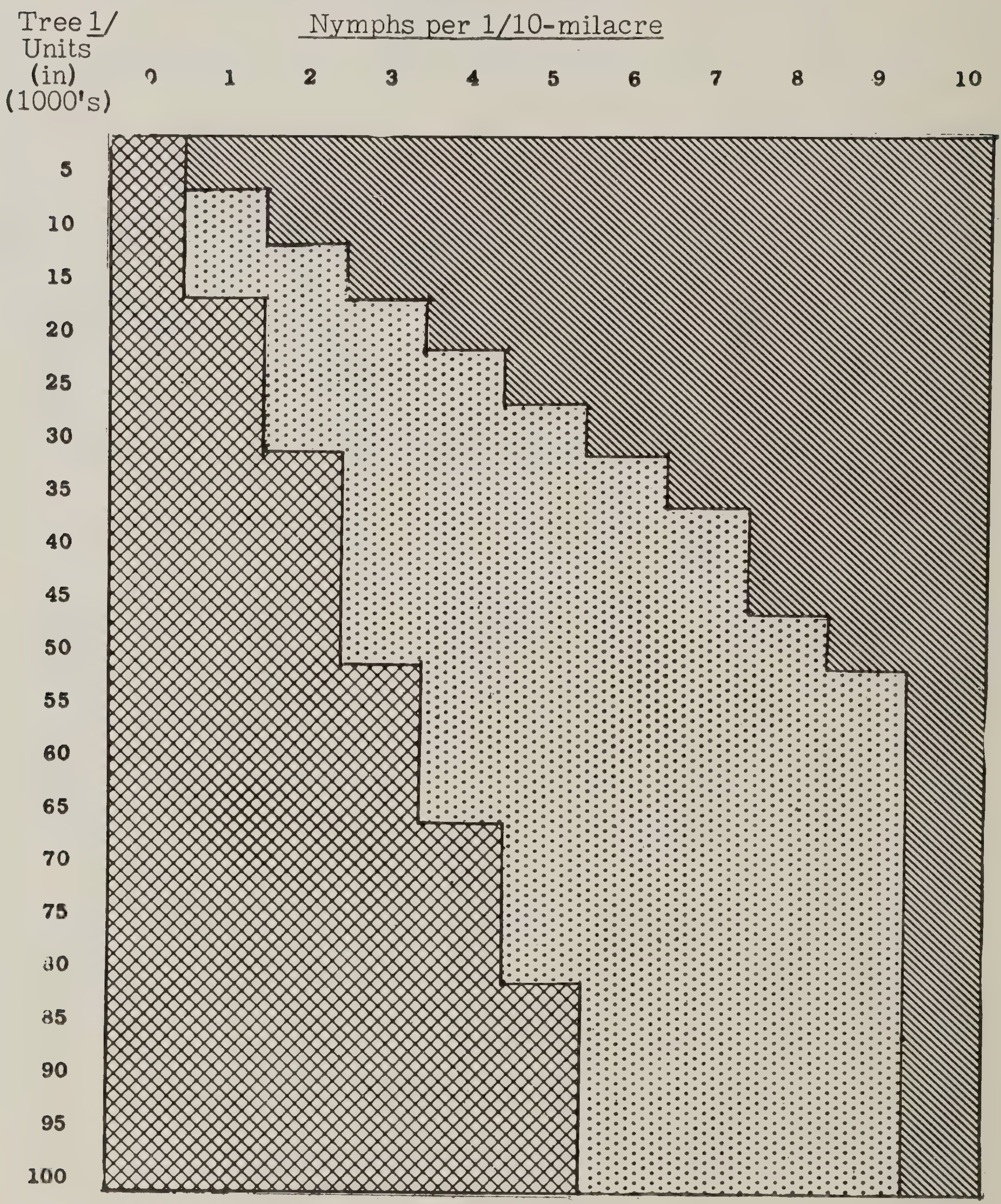
Average number trees per acre: ____________ Average number of branch whorls________

Average height of trees (to nearest foot): __________

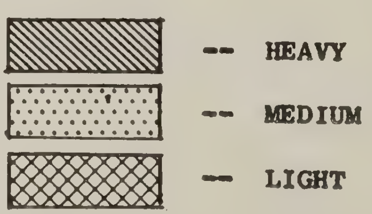
Remarks:

*A continuation sheet is used when there are 20 sample plots.

Saratoga Spittlebug Damage Prediction Table



1/ A product of the average tree height (in feet), the average number of living branch whorls, and the average number of stems per acre.



Spruce Budworm Detection Survey in the Lake States Region

J. L. Bean 68/ and H. O. Batzer 69/

The spruce budworm (Choristoneura fumiferana (Clemens)) detection survey provides general information on annual population fluctuations at fixed locations, data on areas of heavy defoliation not previously observed, and quantitative information on budworm abundance at various locations throughout the spruce-fir type.

Survey Procedures

Location of collecting point.--The permanent collecting points should be established in accessible balsam fir stands of several acres in size, and distributed so as to give good coverage of the spruce-fir types in each State. The area in which the collecting point is established should not be subject to cutting for at least 10 years. These points should be established in budworm-susceptible stands; the insect itself may or may not be present. Adequate coverage should be obtained if a minimum of 10 collecting points are established in each of the State's forest districts. Where private, State and Federal holdings occur in the same district, the State will be responsible in apportioning the number of points to be established by each. These points can be established at any time to avoid delay at the time of taking records.

Selecting trees to be sampled.--Adjacent to the reference point three balsam firs suitable for beating are selected and marked with paint, using one, two, and three diagonal lines. These same three trees will be sampled annually for budworm larvae and defoliation. The selected trees should be: (1) Typical of the surrounding stand, (2) just within or at the edge of the stand, (3) as bushy as possible, (4) at least 25 to 30 feet tall, and (5) with live limbs in full sunlight close to the ground. Small trees growing closely with or beneath larger trees may be used, also trees along roads, around fields, campgrounds, or similar openings. At each collecting point a centrally located tree or post should be permanently marked (preferably with paint) with the number of the collecting point and a symbol designating the established agency.

Taking plot data.--Numbers 1 through 9 on the Spruce Budworm Detection Survey form shown on page 69 are self-explanatory.

Number 10--List each major tree species, starting with the most abundant species; estimate the average height of each species and percent occupied in the overstory.

Number 11--Estimate length of live crown and average basal width in feet. When one side of live crown is shorter than the other because of shading, determine average from both lengths. The same procedure will be used for basal width.

68/ Forest Pest Control, Forest Service, USDA, Upper Darby, Pa.
69/ North-Central Forest Experiment Station, Forest Service, USDA, St. Paul, Minn.

Sampling procedure.--Sampling for the budworm at each collecting point will be made after the larvae have reached the fifth stage in the following manner: (1) Place the collecting sheet on ground beneath outer crown of sample tree--at least half of the sheet should project beyond the outer crown of perimeter on the leeward side, (2) using the long pole, brush the lower 10 feet of the live crown directly above the sheet with five heavy downward strokes, (3) count all budworm larvae and pupae falling onto the sheet and record the number for each tree sampled, (4) estimate defoliation of current growth for each tree sampled as follows: None, no defoliation evident; light, a trace up to 20 percent; medium, 21 to 50 percent; and heavy, over 51 percent. Divide crown into three levels and estimate defoliation in each part. The average of these three estimates will be the degree of defoliation for the entire tree. When no budworm larvae are recovered from the beating or no defoliation is observed, those items should be recorded on the form.

Reporting Results

A new set of data will be recorded each year the collecting point is visited. The same form can be used for these yearly collections.

Each cooperating agency will prepare a map showing the exact location and number of each collection point established. Copies of this map will be sent to the State agency designated to receive forest insect reports and to the Division of Forest Insect Research, North-Central Experiment Station, Folwell Avenue, St. Paul, Minn. 55101.

After each collection has been made, the completed form should be mailed immediately to the State agency involved. This will include collections made on National Forests. This State agency, in turn, will prepare a yearly summary of these reports for inclusion in the regional report by the Division of Forest Insect Research.

Equipment

The survey has been designed so that a minimum of equipment (listed below) will be needed.

1. One 6- by 8-foot collecting sheet of unbleached sheeting or similar material.

2. Light pole approximately 10 feet long. (This can be cut on the spot and left for use next year.)

3. Paint for numbering trees and marking location of collecting point.

4. Supply of "Spruce Budworm Detection Survey" forms (one copy for each collecting point).

SPRUCE BUDWORM DETECTION SURVEY

(1) Collecting Point No. ____________ (2) State ____________ (3) TRS Forty ____________

(4) Collecting Point Location ________________________

(5) Reporting Agency ____________ Stand Acreage: ____________

(6) Collectors ________________________ (7) Date ____________

(8) Staminate Flowers Present (Balsam Fir) YES ________ NO ________

(9) Stand Description

Species	Average Height	Percent of Overstory

(10) Individual Tree Record

Number	D.B.H.	Crown		Spruce Budworm		Percent of Current Defoliation
		Length	Width	Larvae	Pupae	
1						
2						
3						

INSTRUCTIONS

I. Establishment of Collecting Point:

1. Select permanent sampling points within susceptible balsam fir stands. There should be a minimum of 10 points in each State forest district or comparable sampling unit.
2. At each sampling point select THREE balsam firs, preferably dominant or codominant, which are part of the stand but which are fairly well in the open and have low, living branches.
3. Mark the trees with paint with 1, 2, and 3 diagonal lines; locate them accurately by reference to known points and also on a map.

II. Sampling Procedure:

1. Sampling should be done when the larvae are in the fifth stage or instar.
2. Place collecting sheet (6' x 8') on ground on the leeward side and under the crown of each marked tree, with half of the sheet projecting beyond the perimeter of the crown.
3. With a long pole (10' or more) brush the lower 10 feet of the live crown directly above the sheet with 5 heavy downward strokes.

Instructions continued on following page.

III. Completing Form:

1. Numbers 1 through 8 are self-explanatory.
2. Number 9 - List each major tree species, starting with the most abundant species; estimate the average height and percent occupied in overstory.
3. Number 10 - Estimate crown length and average basal width in feet. Record number of budworm larvae and pupae on sheet. Record defoliation of current growth as NONE when no defoliation is evident; LIGHT - a trace to 20 percent defoliated; MEDIUM - 21 to 50 percent defoliated; and HEAVY - over 50 percent defoliated. Divide crown into three levels and estimate the defoliation in each; the average indicates the degree defoliation for the entire tree.

Spruce Budworm in the Northern Rocky Mountains

T. T. Terrell [70]

Detection Surveys

New outbreaks of spruce budworm (*Choristoneura fumiferana* (Clemens)) are frequently discovered during aerial detection surveys.

Foliar damage caused by spruce budworm is most evident in the northern Rocky Mountains during mid-August. Flights are made from about August 1 through September 15. Before this period, light foliar damage has not turned red enough to be readily seen; after mid-September, fall storms decrease the evidence of feeding.

Flights are made over the timber type from 8 a.m. to about 2 p.m. Shadows are too long on northern and western slopes to permit earlier flights, and rough air terminates the afternoon flights.

For detecting infestations, early morning light is best because it shows red better than noontime light.

Flights are made at approximately 800 feet above the terrain. A contour pattern is flown in most of the area because the terrain does not lend itself to strip flights.

When evidence of spruce budworm damage is discovered, the outbreak areas are mapped on one-half inch to the mile maps.

70/ Forest Pest Control, Northern Region, Forest Service, USDA, Missoula, Mont.

Biological Evaluation--Aerial

Biological evaluations of spruce budworm include an aerial survey of known infestations. These are made in much the same manner as detection surveys. The damage is classified as to degree of intensity--light, moderate, or heavy. These classes cover fairly large areas of perhaps a small drainage or some topographical unit and are described by appearance as follows:

> Light--The damage ranges from barely visible to reddening of the upper one-fourth of the tree crown. Damage is not necessarily continuous throughout the stand. There may be a few heavier spots of damage.
>
> Moderate--Damage is clearly visible. The upper one-third to one-half of the crown is red. The damage is not necessarily continuous, and there may be some heavily damaged spots.
>
> Heavy--Damage is visible on most trees to the bottom of the crown. The damage is nearly continuous throughout the stand. There may be some top killing.

Subsequent ground examinations usually show that aerial observation classes fall into the following percentages of defoliation of current needle growth: Light 25 to 40, moderate 35 to 60, heavy 55 to 85.

Biological Evaluation--Ground

Samples of foliage are collected from the lower midcrown of intermediate trees to determine the number of budworm egg masses. Two samples each of sufficient quantity to cover a 4- by 4-foot canvas are collected from opposite sides of one-tree plots located in various parts of the area surveyed. Twenty to 30 one-tree plots per area are desirable.

Samples are taken in September or October after the eggs have hatched. The foliage, placed in large plastic bags, is brought into the laboratory and stored in a cold room (about 38° F.).

The foliage is measured by spreading it loosely on a canvas-covered table marked gridiron fashion from an end line to show the number of square inches of surface up to 2,000. The excess foliage is discarded.

The percent defoliation of current growth is estimated by examining 50 new growth shoots. The defoliation estimate is useful in determining budworm activity in a given area.

The complement of foliage remaining from previous years is also recorded because it has a bearing on the tree's chance of survival when the current defoliation is severe.

The foliage is then examined. All needles with foreign material attached are removed and placed into pillboxes. These needles are then examined by an entomologist who removes the needles having budworm egg masses. He then separates the current year's egg masses from those of previous years. Old egg masses are discarded because they were found to be invalid as a measure of egg populations for the previous year in the northern Rocky Mountains. Current egg masses are also examined to determine the percent parasitized by <u>Trichogramma</u> sp.

The graph (fig. 1) is used to predict the defoliation for the next season. It shows the correlation between egg masses and subsequent defoliation in the northern Rocky Mountains. The prediction is quite accurate in 3 out of 4 years.

This estimate and all information regarding the past history of the outbreak are the basis of recommending for or against control projects.

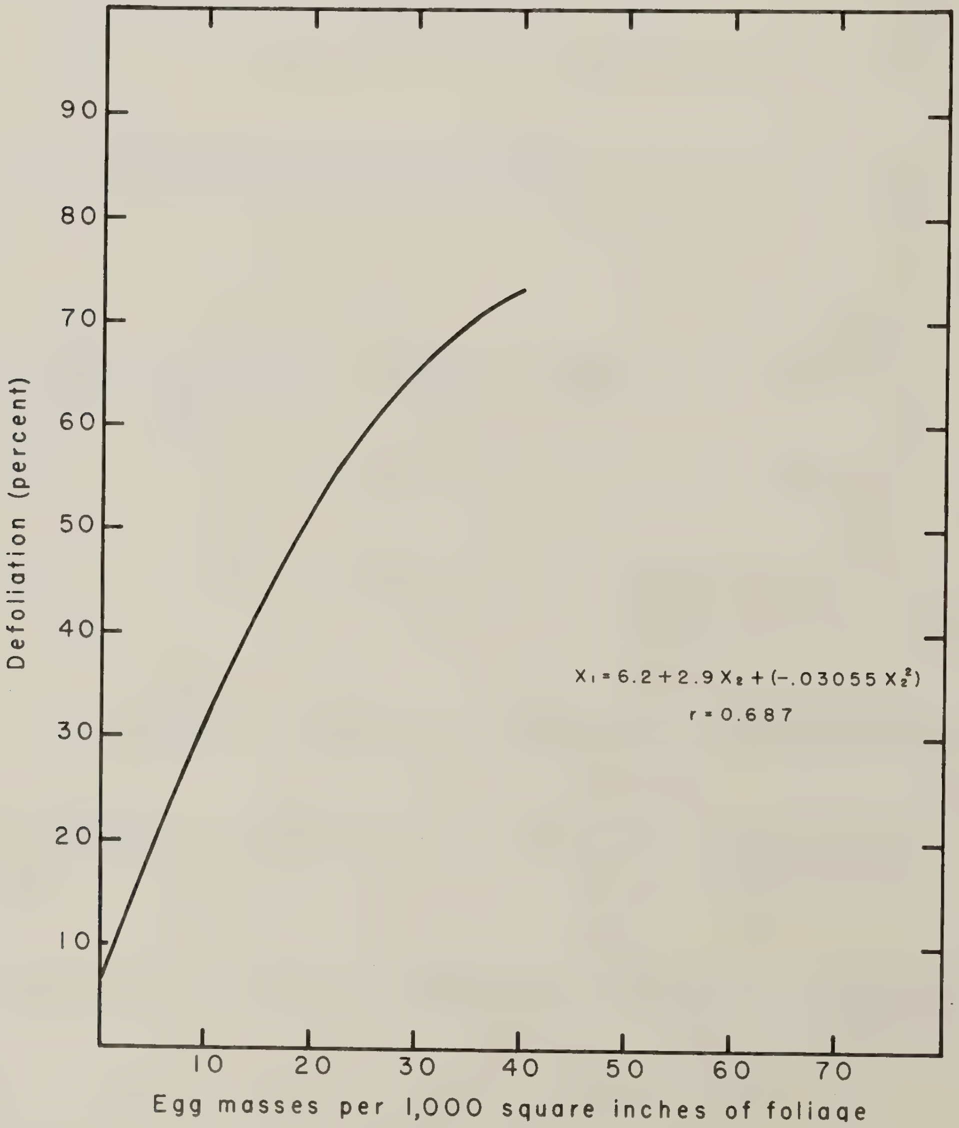


Figure 1. Defoliation resulting from spruce budworm egg masses: 1959-1960, 1961-1962, and 1962-1963.

White-pine Weevil Appraisal Survey in the Lake States Region

S. E. Banash [71]

The white-pine weevil (*Pissodes strobi* (Peck)) has been a serious pest of pines and spruces in the Lakes States region for many years. Infestations can be severe in white, jack, Scotch, and red pines and in Norway spruce. Other species sometimes seriously damaged are Austrian pine and white spruce. Direct control measures to prevent attack have met with some degree of success. An appraisal survey is required to enable the forester and the entomologist to determine the degree of infestation to be used as a guide in making control recommendations.

Survey Procedures

Time of Survey.--The time when weevil attack first becomes evident will depend on the locality, weather conditions, and tree species. For the Lake States, in general, this occurs about mid-June. The effects of weeviling will be readily visible for the remainder of the season.

Method of Survey [72]

This survey involves determination of the percentage of attack presently occurring in a plantation. Data obtained will be classified in categories representing light, medium, heavy, or no weeviling.

The first sample is taken at least one chain from the edge of the planting. At this point the observer tallies 10 trees along the row. To establish the second sample, two chains are paced from the last tree examined. Subsequent samples are taken in the same manner until the end of the row is reached. Additional sample lines are run through the planting at five-chain intervals. When the plantation is not established in rows--some types of underplanting for example--and does not lend itself to line sampling, cluster samples of 10 trees should be taken along a compass line. The intervals should be the same as for regularly spaced rows. A minimum of one sample for each acre of plantation, having less than 1,000 trees per acre, is required for accurate results. Two samples are required for plantations having more than 1,000 trees per acre. The observer may obtain this average number of trees per acre by establishing, at random, three 1/50-acre circular plots (16.6 feet in radius) in each plantation.

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[71] Forester-Entomologist, Ranger Station, Antigo, Wis.

[72] Marty, R., and Mott, D. G. Evaluating and scheduling white-pine weevil control in the Northeast. U.S. Forest Serv. Res. Paper NE-19, 56 pp. 1964.

Tallying Data Sheet

Each sample consists of 10 trees approximately two chains apart. Only the currently weeviled trees should be tallied.

Column: 1. Weeviled trees--current year's weeviling.
2. Nonweeviled trees--can be previously weeviled but not in the current year.
3. Cumulative total of weeviled trees--this column represents the total for the previous plots.

Example:

Plot No.	Weeviled Number	Cumulative total weeviled Number	Non-weeviled Number
1	2	2	8
2	3	5	7
3	1	6	9

Summary of data.--Categories for the seriousness of damage are based on percentage of weeviling arbitrarily established for this survey at the following levels.

Heavy--25 percent or more of the sampled trees weeviled.
Medium--10 to 25 percent of the sampled trees weeviled.
Light--less than 10 percent of the sampled trees weeviled.

Determining the needs for control will vary with values placed on individual plantations by the owner.

WHITE-PINE WEEVIL APPRAISAL SURVEY

Description: T.____ R.____ S.____ Forty:____ Date:____

Host:____ Acreage:____ Age:____ Spacing____

Average Height of Trees:____ Average Number of Trees Per Acre:____

Plot Number	Number of Trees: Weeviled	Cumulative Total	Non-Weeviled	Plot Number	Number of Trees: Weeviled	Cumulative Total	Non-Weeviled
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			
TOTAL				TOTAL			

Citrus

Citrus Red Mite [73]

Herbert Spencer [74] and Allen G. Selhime [75]

The citrus red mite (Panonychus citri (McGregor)), known generally in Florida as the purple mite, has become a major pest of citrus, especially in the past 10 years. Since 1913 the Subtropical Fruit Insects Laboratory at Orlando, Fla., has conducted many experiments with insecticides and miticides for control of this pest, and also experiments designed to reveal the causes of infestation increases. Sampling methods have been devised to measure natural infestations and also the control obtained with the many treatments that were tested.

Sampling for reliable experimental data is at best a time-consuming and expensive work. Several methods have been tried to obtain more reliable data at less cost of time and labor and to find a simple method that might be useful also to citrus growers in checking their own groves.

Our present method of estimating infestations has several advantages. We use a hand lens in the grove to avoid collecting and transporting samples to the laboratory and using the microscope. We examine only top surfaces of the leaves, since that is where most of the eggs and crawling stages of the red mite are found. This is simpler than examining upper and lower leaf surfaces and fruits, and gives larger numbers and less variation for equal time spent.

The hand lens we use is a linen tester with frame having an opening, or field, 1 inch square. The opening is placed diagonally over the midrib on the upper surface of the leaf. Records are made of the numbers of crawling mites and unhatched viable eggs in the square. This is done for 25 leaves equally spaced around the tree at chest level. Mature, hardened leaves just back of the tender new growth are examined, since tender new-growth leaves may not have been out long enough to develop infestations.

Adding the values recorded for each 100 leaves gives a tree estimate, or index, and adding the indexes of four or five trees that get the same spray treatment gives the treatment index. This index may be compared directly with other indexes similarly obtained for other treatments, or those found before spraying or later in the year.

73/ Adapted from Spencer, H. and Selhime, A. G. Sampling of infestations of citrus red mite. Florida Ent. 38(4): 165-166. 1955.

74/ Retired, formerly with Entomology Research Division, ARS, USDA.

75/ Entomology Research Division, Agricultural Research Service, USDA.

The treatment index numbers may be reduced to mites or eggs per square inch if desired. Such indexes may be compared with those obtained in other years in the same grove or in other groves. The percentage of leaves infested from the basic leaf records may be derived, if this is needed for comparison with infestation records so summarized in former years.

Data from infestation estimates made by this new method are better suited for analysis of variance, calculation of experimental errors, and checking adequacy of sample size than data obtained by the percentage method. It is a method capable of showing very small differences in control from different miticides.

There is a decided advantage in recording eggs separately. By doing so, one can decide on the probable red mite-infestation trends in a grove. If there are fewer unhatched eggs than mites on the leaves, the infestation is probably declining naturally and spraying or respraying may be avoided. If the mites run more than two per square inch and eggs four or more, a large increase in infestation may be expected in the near future and immediate spraying is advisable. The index of infestation that calls for spraying can probably be set rather closely when additional data become available.

A grove owner can adapt the method by examining 25 leaves on each of 10 trees well spaced across each grove. One man with a lens and notebook can examine 10 trees in an hour and get information that will help him answer the ever-present question, "Shall I spray these trees for red mites now, or wait?" And he can come back 10 days after the spraying to determine whether or not his efforts have been successful.

Grapes

Grape Root Borer

V. G. Attwood [76], W. D. Wylie [77], and W. P. Boyer [77]

Survey Method Used in Arkansas

A survey method for grape root borer (*Vitacea polistiformis* (Harris)) has proved successful in determining the extent of adult emergence in Arkansas. The number of larvae in roots cannot, of course, be determined without destroying the vines. The adult moth is often mistaken for a common wasp when seen flying about a vineyard.

76/ Pine Bluff Arsenal, Ark.
77/ Department of Entomology, University of Arkansas, Fayetteville, Ark.

The life cycle of the grape root borer requires 2 years. In northwestern Arkansas, adults are present in the field from mid-July to mid-August. The adult female deposits over 400 eggs, enough for one egg per vine for an entire acre of grapes. The eggs hatch in 2 weeks. Only about 10 percent of the larvae become established, and these spend 22 months in the roots. The pupal stage lasts 4 to 5 weeks. The remaining 3 to 4 weeks are required for the adult and egg stages.

One survey method has proved successful. At the time of adult emergence, about one-third of the pupal case extends above the surface of the soil. After the adult emerges, the empty pupal cases will remain intact. Ninety percent or more of the adults emerge within a 1-foot radius of the base of the vine. Searching under the vine for the remaining pupal cases during the last half of July and all of August will reveal the presence of the root borer. In some vineyards, to easily find the pupal cases, it may be necessary to clean away trash and vegetation from the base of vines before pupation. Increasing use of herbicides in Arkansas vineyards has reduced this problem. By frequent observation, adult emergence will be noted before the empty pupal cases are destroyed by rain.

Western Grape Leaf Skeletonizer

A. G. Forbes 78/

The Bureau of Entomology in the California Department of Agriculture has been engaged in an intensive campaign directed against the western grape leaf skeletonizer (Harrisina brillians Barnes and McDunnough). This insect, which is a day-flying moth, is found on wild and domestic grapes in a wide range of climatic niches ranging from coastal plains to desert canyons and at elevations from sea level to 4,500 feet.

Visual inspection has been found to be the only acceptable method of survey. Extensive bait trap studies have been conducted in search for an attractant that would satisfactorily supplement visual inspection, but nothing of outstanding effectiveness so far tested has been found. The most promising of these tests has involved a preparation made through the addition of the abdominal tips of virgin female moths to benzene. This has shown an attraction to males but has not yet been developed to the point where it can be used on a practical basis.

In the matter of visual survey, the presence of adults is most easily observed. They have a wing expanse of approximately 1 inch and have an iridescent blue-black metallic color. They usually emerge from overwintering pupae sometime soon after April 15 and are again abundant in July and to a lesser degree in September. If present and forced into flight, they are inclined to

78/ Bureau of Entomology, California Department of Agriculture, Sacramento, Calif.

flutter around and return to the vine from which they were originally disturbed. Adults are inclined to favor the lower part of the vines, both wild and cultivated, and it is on these lower levels that inspection is concentrated. Actually, the adults are very retiring and tend to drop rather than fly when disturbed, making detection somewhat difficult in the absence of heavy populations.

The lemon-yellow elliptical eggs are generally deposited on the under surface of the leaf. They are laid on end, slightly separated, in more or less irregular rows making up patches of from 20 to 100 eggs. They are not greatly dissimilar from those deposited by the smaller more common lady beetles. Their presence can be easily overlooked unless a leaf by leaf inspection is being made.

The characteristic feeding damage of the gregarious larvae is very conspicuous and easily noted on badly infested canes at a distance up to 200 feet.

Larval feeding up to the fourth instar is carried out on the under surface of the leaves, producing an extremely thin tissue paperlike area, which is white and translucent when fresh and later turns brown. As the larvae mature, the leaf surface is completely eaten. The earlier larval instars are conspicuous because of their feeding as a colony, side by side, in a steadily advancing line. The mature larvae are also conspicuous because of their brilliant blue and yellow lateral rings that alternate over the length of the body. On severely infested vines nothing remains but the canes, fruit, leaf petioles, and the major part of the midrib.

Pupation occurs under the rough bark of infested vines, usually close to the ground level and even in the grass roots several inches away from the base of the vine. The pupae are relatively flat, yellow to dark brown depending on age, and encased in a white opaque cocoon. Inspection for pupae even during the dormant period is generally deemed impractical because of the time element involved.

Initial infestation is usually found in the border rows in vineyards. The original hour-glass pattern of inspection was for that reason subsequently changed to a peripheral survey including the first five to ten rows in vineyards in areas suspected of infestation. Although there is considerable overlapping during the active season, the various stages closely follow the normal pattern in relation to the generations discussed under adults.

Apple Maggot Fly Emergence

W. D. Whitcomb 79/

In late August and early September, apples infested with apple maggot (Rhagoletis pomonella (Walsh)) are placed in a large box having a 1/4-inch mesh wire bottom. The box is raised 10 or 12 inches on corner legs. Under the box is a tray with 1-1/2- to 2-inch sides where the maggots drop after they complete larval feeding in the apple. Daily and sometimes twice daily the maggots are collected, counted, and distributed among the soil boxes. Soil boxes are 1-1/2 x 3 feet (size is not important) with sides 8 to 10 inches high. They are filled with 6 to 8 inches of good porous soil.

Maggots are distributed among the boxes each day rather than putting each day's collection in one of the boxes. The usual number of maggots in each box is 300 to 400. When the maggots are gathered from the tray, all prepupae and pupae are discarded and the soil boxes are checked frequently to remove any specimens that fail to enter the soil normally.

In late fall the infested soil boxes are placed in or near the orchard and buried even with soil surface. They may be covered with wire or brush to protect them from dogs or other animals. In early June cages are placed over the soil boxes to collect the flies when they emerge. These cages are about 3 feet in each dimension covered with screen wire on at least two sides and cloth sheeting on the top and other sides. The front is attached on two edges with thumbtacks so that it can be folded back to reach in to collect and count the flies. During the emergence season the flies are collected daily. Winter mortality in these cages has ranged from 40 to 60 percent and progressive emergence estimates are based on a 50-percent natural mortality.

Mites in Fruit Orchards 80/

Merrill L. Cleveland 81/

Orchardists and research workers have been trying to estimate mite populations in fruit orchards. Probably the most common method is the use of a hand lens to count mites on individual leaves. A 9- or 10-power lens is recommended if eggs or minute details are to be observed. A 3- or 4-power magnifier permits a faster examination and is generally adequate if only adults and nymphs are being inspected. A variation that adds greatly to the speed and freedom of movement is a headpiece magnifier or a bionocular loupe. When greater accuracy is desired, a binocular microscope is used in the field and in the laboratory.

79/ Waltham Field Station, University of Massachusetts, Waltham, Mass.

80/ Cleveland, M. L. Methods of determining orchard mite populations. Ent. Soc. Amer. No. Cent. Branch Proc. 15: 50-51, 1960.

81/ Entomology Research Division, ARS, USDA, Vincennes, Ind.

A number of methods have been employed in surveying an area to determine the species present. One method requires a funnel with a screen-wire cap over its top. As branches are tapped on the top of the funnel, mites fall from the leaves through the screen into a vial attached to the bottom. Another method involves a box equipped with a screen-wire top and a removable tray. The tray has a 4- by 4- by 3/8-inch depression lined with white cardboard. The box is used in much the same manner as the funnel. The cardboard in the tray can be dry or coated with an adhesive material that traps the mites.

Most of these techniques have been used at the Vincennes, Ind., laboratory. The method now used most commonly is described herein.

Uniformity of samples from field spray plots is maintained by collecting leaves for examination around the periphery of each tree. The sampler picks them at random at shoulder height and at arm's length into the tree as he walks around it. A sample of 100 leaves, equally divided among the replications, is taken for each treatment. The samples are then placed in quart ice cream cartons, marked according to treatment and replication, and taken to the laboratory. If the plots are nearby, a simple metal tray is used to carry the cartons; if plots are farther away, cartons are transported in an insulated ice chest.

Upon arrival at the laboratory, samples are refrigerated at 40° to 50° F. Refrigeration permits a delay in counting for at least 3 days. Dehydration of both mites and leaves occurs after 5 days. Mites will begin to migrate shortly before wilting of the leaves becomes noticeable.

Mites and eggs are removed from the leaves to glass plates with a brushing machine (Henderson, McBurnie 82/). An application of either clear varnish 83/ or a 1 to 1 mixture of Tween 20 and ethyl alcohol acts as an adhesive. The plates are normally examined immediately, but they may be stored in a refrigerator overnight. Moisture condenses on the plates during refrigeration but this is nothing more than a nuisance.

A binocular microscope set at a magnification of 20 to 25X is used in counting mites and eggs on the plates. The microscope is equipped with a counting plate similar to that described by Klostermeyer and Rasmussen 84/. The counting plate is white and has four light-blue bands crossing at equal angles in its center. Each band comprises 5 percent of the total area. At a magnification of 20X, a band nearly fills the field of view. When the glass plate holding the mites is placed over this counting plate, any part may be examined readily. A valid estimate of the population can be made from one

82/ Henderson, C. F., and McBurnie, H. V. Sampling technique for determining populations of the citrus red mite and its predators. U.S. Dept. Agr. Cir. 671, 11 pp. 1943.

83/ The varnish may be easily removed by boiling the plates in a solution of 4 ounces of trisodium phosphate per gallon of water.

84/ Klostermeyer, E. C., and Rasmussen, W. A counting plate for sampling mite populations. Jour. Econ. Ent. 49(5): 705-706. 1956.

band if the number of mites exceeds 200, from two bands if it is between 100 and 200, and from four bands if between 10 and 100. The total plate area should be examined if there are less than 10 mites per band. This operation can be expedited by using a ruled background.

The European red mite (_Panonychus_ _ulmi_ (Koch)), the two-spotted spider mite (_Tetranychus_ _urticae_ Koch), and the four-spotted spider mite (_T._ _canadensis_ (McGregor)) are the phytophagous species generally found on fruit trees in the Midwest. Their habits vary considerably. European red mites begin feeding in early spring and can be a serious problem by petal fall. Upon hatching from overwintered eggs, they feed on the first leaves that appear. While terminals are probably first to be attacked, it is only a short time before the tree is rather uniformly populated. Two-spotted spider mites begin feeding somewhat later and are first noticed in the center of the tree. Some females hibernate under the bark, but many pass the winter beneath leaves and debris in the orchard. Mites that overwinter on the ground generally feed on the cover crop before migrating to apple foliage.

Habits of four-spotted spider mites are similar to those of two-spotted spider mites, but they appear to be more confined to the tree. Their feeding on apples, although possibly not so pronounced, is often earlier than that of the two-spotted spider mites. In determining populations of these two species, it is often necessary to take half of the samples from the center of the tree. It is essential that the same sampling technique be followed on all trees and all treatments involved.

Pear Sawfly

Plant Pest Control Division

Pear sawfly (_Hoplocampa_ _brevis_ (Klug)), an economic pest of pear in Europe, was discovered in Canada in 1964. Federal taxonomists reviewed specimens of this sawfly group in the United States National Museum and found _H._ _brevis_ adults had been submitted from Newburgh, N.Y., in 1953 85/. Survey for this pest is indicated in all pear-growing areas of the country, especially in the Northeast.

Survey Procedures

Adults of pear sawfly are needed for positive determination. They are difficult to collect. L. W. Boulanger of the University of Maine used sticky-board traps placed in pear orchards to capture the adults taken in New York in 1953. He favors this method; however, specimens may be badly damaged by collection on sticky boards, if they are not handled properly. The collector should carry a small bottle of petroleum solvent, such as Varsol, and a medicine dropper. A few drops of solvent on the specimen to be removed will

85/ Plant Pest Control Division. Pear sawfly (_Hoplocampa_ _brevis_ (Klug)). U.S. Dept. Agr. Coop. Econ. Insect Rpt. 16(4): 62-64. 1966.

quickly soften the sticky material. The specimens should then be placed in vials containing the same solvent. Generally, by the time the specimens are to be checked, the sloshing motion has dissolved the sticky material. The specimens are then placed on paper towels and transferred to alcohol.

Promising captures on sticky board traps should be followed up by sweeping the pear blossoms with a sweep net. About one trap per acre in selected pear orchards would be sufficient for an exploratory detection survey. The trap should be exposed in the lower part of the tree but high enough to be beyond the easy reach of children or animals. In Canada, G. G. Dustan, Canada Department of Agriculture, reports that adults of pear sawfly were so scarce in Ontario in 1965 that only three were recovered. These were obtained by tapping limbs over a cotton sheet.

Survey for larvae in Canada was conducted by scouting in pear orchards for the characteristic hole in the side or calyx end of the small fruits. Suspected fruits were cut and examined. About 20 minutes were spent in each orchard. According to European literature, a good method for survey would be to cut and examine fruit that falls in the "June drop." Attacked fruit, according to reports, falls at an early stage and a massive drop may be indicative of the presence of the pest. Attempts should be made to rear the insect to obtain adults where they cannot be collected in adequate numbers.

Timing of surveys.--Timing of survey is highly important in detecting this insect. Adults are active for around 10 days only and larvae about 20 to 25 days. Adults appear when the pear blossoms begin opening; therefore, traps should be placed in orchards just ahead of this time and kept in orchards until the petals fall. Observations in 1965 on life history in Canada were as follows: First adult was collected on May 12 when pear blossoms were 75 percent open. First adult emerged from soil in insectary May 17. Newly hatched larvae and unhatched eggs were found May 19. No larvae could be found in the fruit after about June 15.

Stone Fruits

Cherry Fruit Fly

D. W. Robinson [86]

Methods Used in California

Three methods of detecting cherry fruit fly (*Rhagoletis cingulata* (Loew)) infestations have been used in Siskiyou County, Calif.

[86] Bureau of Entomology, California Department of Agriculture, Sacramento, Calif.

Detection of Adults

Adults may be trapped with a sticky-sided carton baited with ammonium carbonate. Quart-size Sealright Thermorex paper containers are used with the inner surfaces coated with Mapco Stickem Special. The trap is attached to a tree with a wire that extends through the bottom and has a small hook on the inside on which the bait packet is hung. Approximately 2 ounces of powdered ammonium carbonate is sealed into 2-inch square plastic packets. The packets remain sealed until time of use. When they are to be used, 10 to 12 perforations are made. The bait is replaced in the traps at weekly intervals. Traps are placed, when convenient, at a height of about 8 feet above the ground on the southeast side of the tree. Traps are generally replaced once or twice during the 3-month trapping season.

Detection of Larvae

Larvae are detected by processing fruit samples. One-pound samples of cherries are crushed by running them through an old-fashioned, hand-operated clothes wringer with rollers grooved and set apart so as not to crush the pits. The crushed fruit is placed over 1/4-inch mesh screen in hot water, preheated from 140° to 160° F., for at least 1 minute. The fruit is then discarded. The remaining pulpy water containing the larvae, if any, is placed in a pan in a swirling device propelled by a small electric motor. Rotation speed is controlled by a rheostat. In the swirling water, larvae and other heavier particles gravitate to the center of the pan where the greatly reduced level of water permits easy detection.

Detection of Pupae

Pupae are detected through soil sifting. Soil within the drip line of the tree is sifted through mesh screen (6 wires per inch) to eliminate large particles then resifted through a smaller screen (14 wires per inch) to eliminate fine soil. The remainder is inspected visually for puparia. This method of detection has been used primarily to confirm infestation on properties where adults were taken in traps, but no larvae found in fruit samples processed.

Plum Curculio--Survey Methods

Roy W. Rings [87]

The examination of fruit at harvest for plum curculio (*Conotrachelus nenuphar* (Herbst)) injury is an unreliable survey method since most fruits attacked by this insect fall to the ground before harvest. The collecting of dropped fruits and the rearing of larvae from these fruits are reliable research methods; however, the methods are too time consuming for survey entomologists.

87/ College of Biological Sciences, Ohio State University, Wooster, Ohio.

The most reliable method for determining adult populations is the jarring method. This consists of vigorously jarring or shaking individual branches of the tree over a "curculio catcher." The catcher may consist of an umbrella that is lined on the inside with white nylon. The stem of the umbrella may be cut off about half-way between the handle and the junction of the stem with the cloth top for ease of handling in collecting. A less expensive catcher can be made by mounting a 2-feet by 4-feet piece of white cloth on a collapsible wooden frame in such a manner that the borders of cloth are elevated and the center of the cloth depressed to form a concave collecting surface. Both of these catchers, if properly constructed, have the advantage of requiring little storage space.

Jarring procedure consists of holding the catcher in one hand just beneath the branch to be jarred and vigorously shaking or jarring the branch with the other hand. To avoid skin abrasions, wearing a heavy cloth glove on the jarring hand is advisable. Mechanical jarring devices, such as rubber mallets, cause bark abrasions that may become infected with disease or infested by borers.

Because trees vary in size and fruit crop, jarring for a given interval of time is desirable rather than jarring a given number of trees. For example, sampling may be done for a period of 4 to 5 minutes. At the end of the sampling period, the catcher is examined for plum curculio adults. At least four sampling periods from different areas of the orchard are required for a fairly reliable estimate of the population. Many of the adults feign death; and, therefore, the examination must be critical. Also, other Conotrachelus that resemble the plum curculio may be collected. All curculios should be checked for the presence of two larger and two smaller, shining-black protuberances on the dorsal surface of the elytra. If the curculios lack these features, they are not plum curculios.

In selecting trees for sampling, it is well to consider that plum curculios will be found in greater numbers on trees at the edge of the orchard than in the center. This is particularly true on trees bordering woodlands. Also, more curculios will be found on trees bearing a good crop of fruit than those with light crops or without fruit. It is also well to remember that curculios will begin to emerge from hibernation at or just after bloom and will increase in numbers during the next few weeks. Very few curculios will be found after July 1 since the adults of the first generation occur at this time and are comparatively inactive.

Sampling should be done as early in the morning as possible when temperatures are comparatively low because the curculios will drop directly into the catcher. In late morning and in the afternoon, the beetles become more active and are more likely to fly, and thus escape the catcher.

This technique may be used to detect the first appearance of plum curculio in the spring and to compare populations in one area with those in another.

The method may also be used to estimate populations of plant bugs and stink bugs that attack fruits.

Plum Curculio--Technique in Jarring 88/

W. D. Wylie 89/

Survey Methods Used in Arkansas

Jarring trees to obtain plum curculio (*Conotrachelus nenuphar* (Herbst)) adults is an old and well-established practice. At one time this method was considered a valuable supplementary control measure for plum curculio on peaches. Although no longer practiced as a control measure, jarring trees is still considered a valuable tool particularly in research. Jarring is useful as a means of timing spray applications and for locating areas of heavy infestation. It may also be used as a criterion for evaluating effectiveness of spray applications.

Equipment and technique for jarring are described in this paper. The method described was used with satisfactory results during 1949 and 1950 in the peach belts in the Arkansas River Valley centered around Clarksville and in the southwestern belt near Nashville.

In tree-jarring experiments in Arkansas, a sheet 4 feet by 7 feet is attached to a light wooden frame. The frame is hinged for folding to facilitate transporting from one orchard to another. Other equipment includes a light rubber-covered mallet 90/ and a small bottle fitted with a slit-rubber top for collecting the beetles.

The procedure involved in using the small jarring sheet is to hold the sheet in one hand and with the mallet jar the limbs by one or two sharp blows. No attempt is made to jar an entire tree. The beetles are usually collected at the end of the jarring period. If, because of high temperature, the beetles become active, they are captured and counted immediately. The unit of measurement of curculio abundance is based on the amount of time spent in jarring. In most cases, a 5-minute period is used. If a complete record in an area is desired, four units of 5 minutes each are taken. Usually, the operator jars the limbs on one side of a tree and then moves on to the next tree.

The principal disadvantage in using a small sheet to jar for 5-minute periods seems to be that customarily one thinks of curculio populations as the number per tree. Since this number is an arbitrary figure and is at best only an approximation, a different unit of expressing density of population should be equally satisfactory. The number of limbs jarred in 5 minutes by different individuals will undoubtedly vary somewhat, but this variation should not be nearly so great as the differences between individual trees.

88/ Adapted from Jour. Econ. Ent. 44(5): 818-819. 1951.
89/ Department of Entomology, University of Arkansas, Fayetteville, Ark.
90/ See previous article, Plum Curculio--Survey Methods, for difference of opinion as to the use of rubber mallet.

In the past, jarring records have been on the basis of the number of curculios obtained per tree. This system has numerous disadvantages. The size of trees varies greatly from one orchard to another because of differences in age and growing conditions. Curculio population varies greatly among trees of fairly uniform size. This necessitates a large sample to obtain representative data. It is difficult to jar an entire tree especially if it is a large one. Unless considerable labor is available the sheets must be placed on the ground. Uneven terrain and weed growth make this impractical in many orchards.

During the summer the temperature is too high in Arkansas for satisfactory jarring during most of the daylight hours. The beetles are more active and many of them fly upon being disturbed. More records can be taken during that period of the day when conditions are favorable if the small sheet is used to jar individual limbs rather than entire trees. Also, the small sheet can be held close to the limbs where the curculios are located. Fewer beetles will fly before hitting a sheet held close to the limbs than a sheet on the ground. Also, more beetles can be recovered from the sheet on a rigid frame since they can be removed more quickly from it than from large sheets. Thus, jarring can be done with the small sheet when high temperature would make the use of large sheets on the ground impractical.

Sheets sufficiently large to cover the area under a large peach tree require several persons to hold them. The only alternative is to place them on the ground. In many Arkansas orchards the terrain is too rough to place the sheets on the ground satisfactorily. With the sheets on the ground it is difficult to jar the tree without walking on the sheets. If placed on bare ground, the sheets soon become soiled; thus, making it difficult to locate the curculios on them. The small sheet on a frame eliminates these difficulties.

The advantages of considering the number of curculios jarred in a 5-minute period using a small sheet on a rigid frame as the unit of measurement may be summarized as follows: Only one person is needed to take the records. More records can be taken at the same time. Difficulties because of variations in tree size, uneveness of terrain, and high temperature are decreased or eliminated.

INSECTS AFFECTING LIVESTOCK AND DOMESTIC ANIMALS

Survey Methods for Livestock Insects

R. A. Hoffman 91/, Roger Drummond 92/, and O. H. Graham 92/

Cattle

Grubs.--Examine animal's back by gently running hands over infested area. An animal, unless gentle, should be confined to chute or stanchion during examination. Check at least five head, or 10 percent of herd. Average number of grubs less than five per head is considered light; five to 15, moderate; and over 15, heavy.

Horn flies.--Count or estimate the number of flies on at least five animals, or 10 percent of herd, by counting the flies on one side of the animal and multiplying the number by two. Binoculars to observe horn flies from a distance are often valuable. In the heat of day, the flies congregate on the lower, shaded parts of the body and are difficult to observe. Average number of horn flies under 50 per head is considered light; 50 to 200, moderate; and over 200, heavy.

Horse flies and deer flies.--Count total number of flies on 15 head as observed from one side and compute the average. Binoculars to observe horse flies and deer flies from a distance are often useful. Average number of flies less than two per head is considered light; two to five, moderate; and over five, heavy.

Lice, biting.--With animal confined, examine at least five 1-inch-square areas on poll, neck, back, and withers. Average number of biting lice under three per square inch is considered light; three to 10 moderate; and over 10, heavy.

Lice, sucking.--With animal confined, examine at least a total of five 1-inch-square areas on dewlap, neck, poll, about the eyes, and muzzle. A portable light is helpful. Average number of sucking lice under three per square inch is considered light; three to 10, moderate; and over 10, heavy.

Stable flies.--Preferred feeding areas of stable flies are on the legs and under parts of the body; but, during hot weather, the flies largely remain off the host during the middle of the day. To avoid confusing stable flies with house flies, one should observe them at close range or through binoculars. Count the flies on the outer legs of one side and the inner legs of the other on at least five head of cattle and multiply by two the total number on each head. Average number of flies under five per head is considered light; five to 10, moderate; and over 10, heavy.

91/ Entomology Research Division, ARS, USDA, Plant Industry Station, Beltsville, Md.
92/ Entomology Research Division, ARS, USDA, Kerrville, Tex.

Ticks.--With animal confined, examine a 6-inch-square area on the dewlap, side of the neck, and escutcheon, and record the average number of adult ticks per area. This method is especially applicable for *Amblyomma americanum* (L.) and *Dermacentor* spp. For *A. maculatum* Koch count the number of adult ticks on the outside of the ears. For ear tick (*Otobius megnini* (Dugès)), count total number inside the ears. Average number of ticks under five per head is considered light; five to 20, moderate; and over 20, heavy. Examine at least five animals, or 10 percent of herd, whichever is greater.

Hogs

Lice.--In warm weather, hog lice are commonly distributed over the animal, but when it is cold, they often concentrate about the ears, between forelegs and body, or between the hind legs. Average number of lice under five per hog is considered light; five to 15, moderate; and over 15, heavy.

Horses

Bots.--Horse bot adults lay their eggs on the hairs of horses, especially on the forelegs, chest, lower neck, and about the mouth. Count the number of eggs (nits) attached to hairs on these body areas. Count eggs on hairs in 10, 1-inch squares on foreparts of the horse's body. Average number of bots under two per square inch is considered light; two to five, moderate; and over 5, heavy.

Ticks.--Examine an area of about 6-inch square on the neck and breast and count the number of ticks per area. Average number of adult ticks under five per 6-inch-square area is considered light; five to 20, moderate; and over 20, heavy. For the tropical horse tick, *Anocentor nitens* Neumann, examine the inside of the ears for engorging adult ticks. An average number of ticks under five is considered light; five to 20, moderate; and over 20, heavy. In exceptionally heavy infestations, ticks may be found on mane, forehead, and between hind legs.

Poultry

Lice.--Count motile forms in seven openings of the feathers: One at vent, two at breast, one at back, one at neck, and one on forward edge of each wing. Examine at least 10 birds. Total count of under 10 per bird is considered light; 10 to 25, moderate; and over 25, heavy. The body and shaft lice are the more common species, but the fluff, wing, and neck lice are also seen. For survey purposes, a differentiation is generally not necessary.

Mites, fowl (northern and tropical).--The fowl mite completes its cycle on the chicken, attaching its eggs to the feathers. Feathers of infested birds become discolored from the accumulation of excrement and eggs. Part feathers at five locations between vent and peak of breast; on one feather from each location count the mites. Average count of less than two is considered light; two to five, moderate; and over five, heavy.

Mites, roost.--Examine at least 10 cracks or joints or both in roosts and nests with the aid of a strong light. Often it may be necessary to pry boards apart slightly to make satisfactory observations. Average count of less than two is considered light; two to five moderate; and over five, heavy.

Sticktight flea.--Examine neck, head, wattle, and around eyes of at least 10 birds for attached fleas. Average count of sticktight flea of less than five per bird is considered light; five to 10, moderate; and over 10, heavy.

Ticks.--Five birds are examined for attached larvae under wings, on sides of body, and on inside of thighs. Average count of less than five larvae per bird is considered light; five to 10, moderate; and over 10, heavy. Adult ticks hide in cracks of the buildings, roosts, nests, or in debris, such as sacks, papers, or accumulated duff. Examine 10 such situations with the aid of a strong light. Average count of ticks less than three per location is considered light; three to 10, moderate; and over 10, heavy.

Sheep or Goats

Keds.--Count adults on at least 10 sheep by parting wool in 15 different locations to sample all areas of the body. Average count of less than five per head is considered light; five to 15, moderate; and over 15, heavy.

Lice, goats.--Part hair on one side of the goat's body at five places--side of face, neck, back, side of body, and hind leg--on at least 10 goats, or 10 percent of herd. Count the number of lice in a 1-inch section of the part. Average count of one to five per area is considered light; five to 20, moderate; over 20, heavy. Differentiate between biting and sucking lice.

Lice, sheep.--Part wool on one side of the sheep's body at five places--side of face, neck, back, side of body, and hind leg--on at least 10 sheep, or 10 percent of herd. Count the lice in a 1-inch section of the part. Average count of one to five per area is considered light; five to 20, moderate; over 21, heavy. Differentiate between biting and sucking lice. For foot louse, *Linognathus pedalis* (Osb.), examine 4 feet and count lice. One to five per foot is considered light; five to 20, moderate; and over 20, heavy.

Table of Ratings

Pests	How rated	Number of pests per area Light	Moderate	Heavy
Cattle:				
Grubs-----------	Per head	5	5 to 15	15
Horn fly--------	do	50	50 to 200	200
Horse and deer flies---------	do	2	2 to 5	5
Lice, biting----	Per sq. inch	3	3 to 10	10
Lice, sucking---	do	3	3 to 10	10
Stable fly------	Per head	5	5 to 10	10
Ticks-----------	do	5	5 to 20	20
Hogs:				
Lice------------	do	5	5 to 15	15
Horses:				
Bots------------	Eggs per sq. inch	2	2 to 5	5
Ticks-----------	Per head	5	5 to 20	20
Poultry:				
Lice------------	Per bird	10	10 to 25	25
Mites, fowl (northern and tropical)	Per feather	2	2 to 5	5
Sticktight flea	Per bird	5	5 to 10	10
Ticks-----------	Per location	3	3 to 10	10
Sheep or goats:				
Keds------------	Per head	5	5 to 15	15
Lice, goats-----	do	5	5 to 20	20
Lice, sheep-----	do	5	5 to 20	20

Mites on Cattle, Horses, Sheep, Hogs, Dogs, and Cats

L. L. Peters 93/, G. D. White 94/, O. H. Hammer 95/, and C. E. White 96/

In surveying for mites of the genera Sarcoptes, Psoroptes, and Demodex (mange mites, scab mites, and follicle mites, respectively), do not look for the mite, but for small, dry, yellowish scabs, moist scabs, and small, hard, pimplelike lumps, ranging in size from a pinhead to a small marble. Examine the head, neck, withers, base of tail, or inner side of legs. If scabs or pimplelike lumps are found, the animal is apparently infested. Report the percent of animals apparently infested or, to be certain of the infestation, scrape hard over these areas with a dull knife or the edge of a salve tin and examine the scrappings carefully under a microscope. In light infestations, to find the mites it may be necessary to clear the scrappings. Lice will occasionally cause symptoms similar in appearance to those caused by mites. Therefore, in the absence of scrappings or with negative scrappings, examine carefully to be certain the condition is not caused by lice. As scrapping draws blood, treat the wound to prevent infection.

SOYBEAN INSECTS

Insects Found in Soybeans

C. E. White 96/, O. H. Hammer 95/, L. L. Peters 93/, and R. D. Jackson 93/

The Linear Foot Method

Carefully examine all plants on 3 linear feet of row at three or more places in the field and count all insects found. When the plants are large, bend them over the space between the rows and shake them vigorously, then count the insects on the ground between the rows. A cloth or paper laid on the ground to catch the insects will facilitate counting. Insects, such as the bean leaf beetle, fly or hide quickly once they are shaken from the plants. Therefore, shake only 3 feet of row at a time. Report the number of insects per 30 linear feet of row. The linear foot method is used for all leaf feeding insects, especially when the plants are more than 6 inches high and for root feeding insects by examining roots and soil about the roots. The most important insects of which the adults may be found feeding on the leaves and the larvae feeding on the roots are bean leaf beetle, a grape colaspis, Phyllophaga, Japanese beetle, and Sitona. Green cloverworm larvae, corn earworm larvae, cabbage looper larvae, grasshoppers, southern corn rootworm adults, plant bugs, and stink bugs may be found feeding on blossoms, pods, or leaves.

93/ Department of Entomology, University of Missouri, Columbia, Mo.
94/ Stored Products Insects Research Branch, Market Quality Research Division, ARS, USDA, Manhattan, Kans.
95/ Dow Chemical Company, Bio-Products Center, Midland, Mich.
96/ Department of Entomology, University of Illinois, Urbana, Ill.

The Sweep Method

The sweep method in soybeans differs from that in clover and alfalfa. In soybeans, take a sweep along one row of beans. Stand facing a row and reach over the first row and sweep the net along the second row from left to right as far as you can reach in both directions. Count the insects after each sweep as it is difficult to move from one row to another without some insects escaping from the net. Report the number of insects per 100 sweeps. This method is useful in checking populations of bean leaf beetle adults, southern corn rootworm adults, grape colaspis adults, Japanese beetle adults, leafhopper adults and nymphs, grasshoppers, plant bugs, stink bugs, and predatory insects.

Plant-Shaking Methods for Soybean Insect Survey in Arkansas 97/

W. P. Boyer 98/ and B. A. Dumas 98/

The plant-shaking method of survey for soybean insects has been used in Arkansas for several years. With extensive increase in soybean acreage, work was conducted to improve the method by the use of certain equipment. The equipment consists of a piece of heavy white or off-white cloth. Each end of the cloth is folded over a thin piece of 1-inch wood, and the cloth sewn tight so that wood will not slip out of the fold. The finished piece of equipment is 24 x 42 inches with the ends rigid. This cloth can be rolled together and easily handled (fig. 1, A) or unrolled to any length up to 42 inches to fit any row width (fig. 1, B). Row widths vary, however. Most of the fields in Arkansas are planted in 38- or 40-inch rows.

Figure 1. Cloth used in plant-shaking method of survey for soybean insects: A, Rolled, B, unrolled.

97/ Adapted from Boyer, W. P., and Dumas, B. A. Soybean insect survey as used in Arkansas. U.S. Dept. Agr. Coop. Econ. Insect Rpt.
98/ Department of Entomology, University of Arkansas, Fayetteville, Ark.
13(6): 91-92, 1963.

The surveyor enters a field and selects a site at random. For soybeans standing upright, the surveyor stands between two rows facing parallel with the rows. He then unrolls the cloth and slides it forward at ground level under undisturbed plants (fig. 2, A). The surveyor then kneels down, extends each arm forward parallel with the row on either side, and vigorously shakes the vines over the cloth. Approximately 1-1/2 row feet of plants on each row are shaken to give a sample of 3 row feet. The plants are then pushed back from over the cloth and the insects on the cloth are counted. To provide better light the surveyor may stand upright with the cloth above the tops of the plants.

In Arkansas, many plants tend to lean over. This may occur as a result of vigorous growth on the more fertile soils. Other causes are late planting, thick stands, or a combination of both. In these fields, the surveyor faces perpendicularly to a row in opposite direction of the leaning plants (fig. 2, B). The cloth is carefully placed under the leaning plants, with the longer dimension parallel with the row. Plants on 3 row feet of the one row are shaken as described above.

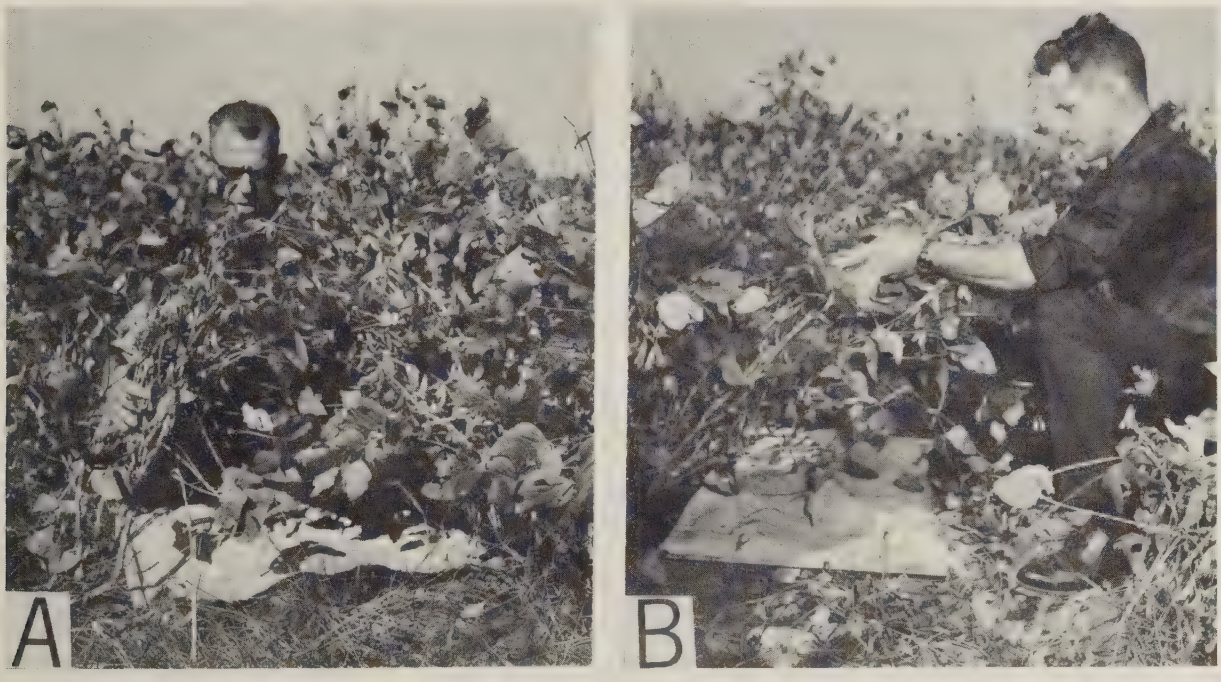

Figure 2. Obtaining soybean insects: A, from upright plants, B, from leaning plants.

Additional sites are selected at random until a minimum of 10 sites have been sampled at locations to give field coverage. Infestations are reported as to number of the various species found on 30 row feet.

This method has proved satisfactory for the various species, except three-cornered alfalfa hopper (*Spissistilus festinus*) adults which are easily disturbed and fly too quickly. The method seems satisfactory for nymphs of this species. (*See* following article, "Three-cornered alfalfa hopper.")

In sampling fields infested with corn earworm (Heliothis zea) larvae, the surveyor must look carefully for large larvae that may fall near the base of the plants or in the opposite middles and miss the cloth. Only large larvae are likely to do this and are easily seen.

In surveying for stink bugs, field coverage is very important as infestations may be very uneven. Special attention should be given to areas in the field near timber. Very vigorous shaking is required for stink bug survey.

Three-Cornered Alfalfa Hopper

W. P. Boyer 99/

Survey Methods Used In Arkansas

Boyer and Dumas 100/ stated that the plant-shaking method of survey adopted in 1963 for soybean insects appeared to be adequate for all current economic pests of soybeans except the three-cornered alfalfa hopper (Spissistilus festinus (Say)). The habits of this species require a different approach.

The adult, an extremely active insect, hops or flies at the least disturbance, whereas the nymph remains in place when plants are examined. During most of the season, nymphs feed on the main stems just above the ground level. A survey method for both adults and nymphs, based on these habits, was established.

A standard 15-inch sweep net was used to survey the adults. The following three methods of sweeping were tested:

1. Walk fast between rows and parallel with rows. In the manner of rowing a boat with a single oar, reach forward as far as possible and sweep the top of one row of beans pulling the net toward the surveyor. Approximately 3 feet of row are swept.

2. Walk fast between rows and parallel with rows. Sweep across the tops of the two rows between which the surveyor is walking.

3. Walk across rows. Reach over a row and sweep 3 feet of tops of plants of second row from surveyor.

Ten sweeps by each method were made 12 times near midday August 30, 1966, in Desha County.

Method No. 1 was adopted. Method Nos. 1 and 2 were much easier to use than Method No. 3. The total number of insects collected by the first two methods was 16 to 18 percent greater than by Method No. 3.

99/ Department of Entomology, University of Arkansas, Fayetteville, Ark.
100/ See previous article.

An easy way to locate nymphs is to bend plants over on 3 feet of row. By this method stems may be observed immediately above the ground level. Make records of the number of nymphs and total number of plants including the number of those girdled and lodged.

The adopted survey method consists of making 10 sweeps and examining 3 row feet, in a nearby area, in each of 10 locations per field. Final data include adults per 100 sweeps and nymphs along with girdled, lodged, and total plants on 30 row feet. Most of these data are quantitative. Plant and nymphal numbers per acre are easily calculated as are percentages of plants girdled and lodged.

STORED PRODUCTS INSECTS

Stored Grain Insects

L. L. Peters [101], G. D. White [102], O. H. Hammer [103], and C. E. White [104]

Selecting the Site

Survey for stored grain insects on a district basis is preferred, because fewer stops per county can be made. A minimum of three stops per county, for the same type of storage, should be made if the survey area is small and you have to survey on a county basis.

Cautions

1. Always contact owner or manager to obtain permission and fumigation history before entering storage areas.

2. Never enter areas under fumigation. Be very cautious about entering grain storage areas that have been fumigated and supposedly "aired" out. If there is a question of safety, do not use this site, but go to another one (areas treated recently should not have many insects). If you must enter such an area, see that doors are open, exhaust fans turned on, and someone standing by to pull you out, if necessary.

3. Never get on surface of grain if grain is being removed from the storage area.

101/ Department of Entomology, University of Missouri, Columbia, Mo.
102/ Stored Products Insects Research Branch, Market Quality Research Division, ARS, USDA, Manhattan, Kans.
103/ Dow Chemical Company, Bio-Products Center, Midland, Mich.
104/ Department of Entomology, University of Illinois, Urbana, Ill.

Forms for Recording Data

Forms may be as simple or as complex as the individual desires. The basic data needed are: County, date, surveyor, type of storage, brief history of fumigation and control, moisture content of grain (moist or dry), temperature of grain, and species and numbers of insects found.

Equipment

A few pieces of special equipment are needed for stored grain insect surveys.

1 - 63-inch long, 1-3/8-inch diameter space partition grain trier.
1 - 6-foot section of eavestrough with one end closed.
1 - No. 10 aluminum insect screen and pan.
1 - 3-gallon metal bucket.
1 - 1-pint measure.
1 - pelican grain sample (for elevator storage).
1 - ear corn probe.
1 - thermometer (range approximately -30° to 120° F.).

Types of Storage

In general, there are four different types of grain storage facilities: (1) Farm-type storage, which may be either wooden or metal bins, usually with less than 3,200-bushel capacity; (2) flat storage, which is usually metal buildings or steel tanks with more than 5,000-bushel capacity; (3) elevator-type storage, which is usually upright concrete, silolike buildings with several-thousand bushel capacity per unit; and (4) cribs for ear corn. Each type of storage requires different techniques in survey so each will be taken up separately.

Commodity Credit Corporation stored grain should not be surveyed on a general survey. This grain is usually well treated to prevent insect damage and would not give a true picture of the insect population.

Sampling Method for Insects in Farm-Type Storage

The grain in farm-type storage is usually admitted during harvest and removed before the next harvest; hence, it generally has only one season of insect infestation. The maximum number of insects is usually found in late September or October; therefore, this is the best time to survey this type of storage.

Take samples with the standard 5-foot grain probe from six locations--the center, about 1 foot from the wall at the four cardinal points of the bin, and the surface. When the bin is first entered, take a surface sample by inserting the closed probe 1 inch deep, parallel to the surface of the grain with the openings up. After the probe is inserted, open it and allow it to fill with grain; then close the probe, withdraw it, and empty sample into eavestrough. Empty the eavestrough into the bucket.

If time permits, sample the entire depth of grain by adding extensions to the trier. Probe the full length of the 5-foot partition grain trier straight down into the grain mass at five points--the north, east, south, west, and central points in the bin. Keep 1 foot away from the wall. If bin is too full to allow the trier to be pushed straight down, push it at an angle so that the point will be 1 foot from the wall.

For shallow bins, one probe from each location is sufficient. If the grain is deeper, from two to three probes must be taken from each location by using extensions on the probe so that samples can be taken from a vertical column from the surface to the bottom of the bin. After each sampling, empty the trier into the eavestrough and empty the material in the eavestrough into the bucket. Mix the samples in the bucket, remove 1 pint of material from the top, pour out the remaining material from the bucket, and retain the last 1-pint sample for examination. Put the two pint samples in the number 10 screen and sieve the debris into the pan. Examine the material remaining on the screen for Indian-meal moth (*Plodia interpunctella* (Hübner)), dermestids, cadelle (*Tenebroides mauritanicus* (Linnaeus)), mealworms, flour moths, Angoumois grain moth (*Sitotroga cerealella* (Oliver)), larger black flour beetles, and other insects too large to go through the screen. Observe the debris in the pan for the smaller insects such as the saw-toothed grain beetle (*Oryzaephilus surinamensis* (Linnaeus)), flat grain beetle (*Cryptolestes pusillus* (Schönherr)), granary weevil (*Sitophilus granarius* (Linnaeus)), rice weevil (*S. oryzae* (Linnaeus)), flour beetles (*Tribolium* spp.), and lesser grain borer (*Rhyzopertha dominica* (Fabricius)).

Because of the time involved, only the top 5 feet of grain are sampled on a general survey. Report the number of insects per 2-pint sample.

Sampling Method for Insects in Flat Storage

The sampling procedure for flat storage is different from farm-type storage because the grain mass is larger and covers more surface area. More samples must be taken. Two surface samples are taken, one in each half of the storage area, midway between the end and center of building. Insert the closed probe parallel to surface of the grain, 1 inch deep with the openings in the trier up, so that the grain falls into the trier when it is opened. The grain trier is probed as in farm-type storage, but the samples are taken midway between the center line and each wall at 15-foot intervals from one end of the building to the other. Mix all samples in the bucket and examine the debris from the first and last pints of grain for the presence of insects. Report the number of insects per 2-pint sample as in farm-type storage.

Sampling Method for Insects in Elevator Storage

The sampling procedure for elevator bins is complicated by the depth of the grain and the difficulty of reaching the surface of the grain from the headhouse floor. The simplest sampling method is to run the entire bin and take samples periodically from the grain stream with a "pelican" sampler, unless special equipment is available to take probe samples from the top of the bin or the elevator is equipped with an automatic sampler. This method takes considerable time and is not always feasible.

Since infestation in elevator bins is most frequently found in the grain at the surface and the bottom of bins, the following method has been adopted for routine examinations.

Caution.--Do not enter bin. Take a surface sample from each bin by lowering an automatic sampling device on a rope to the grain level from the top of each bin. This device consists of a cylindrical container, the two halves of which are held open by springs. On contact with the grain, the two halves snap shut and capture approximately a gallon of grain. A sample from the bottom of the bin is obtained by running the bin for 1 or 2 minutes during which period five passes are made through the falling grain stream with a bucket or a "pelican" grain sampler. If the surface of the grain can be reached by attaching extensions to the probe, take two 5-foot samples with the grain trier. After thoroughly mixing the samples, examine first- and last-pint samples as before. Report the number of insects per 2-pint sample as in farm-type storage.

Sampling Method for Insects in Cribs for Ear Corn

Insert the tip of the ear-corn probe between the boards of the crib and as far into the crib as the depth of the probe. Do this at four equally separated points in round or square cribs and every 15 feet in rectangular cribs. Determine the percent of insect-damaged kernels.

General Sampling

In many instances, moths may be resting on ceilings, exposed bulkheads, and on the grain surface. Record the number per square yard.

Examine piles of dust and debris for insects by screening the material.

Check areas where moisture is high and there are deposits of moldy, spoiled grain for meal moth (*Pyralis farinalis* (Linnaeus)) and psocids.

If a Boerner grain divider is available, it will be useful in cutting large total samples to the amount needed.

SUGARCANE INSECTS

Sugarcane Borer

Ralph Mathes, Leon J. Charpentier, and W. J. McCormick [105/]

Determining Infestation at Harvesttime

Method used in Louisiana.--Surveys to determine sugarcane borer (*Diatraea saccharalis* (Fabricius)) infestations in Louisiana are made at time of harvest each year. Examinations are made at 22 mills located in 15 of the 16 sugarcane-producing parishes that have mills. Two representative mills in each of the parishes producing 6 percent or more of the State acreage and one each in the group producing below 6 percent are surveyed. The survey mills process more than one-half of the total gross tons of sugarcane ground for sugar. Early (October) and late (December) examinations are made at each mill to obtain data on both plant and stubble (ratoon) crops. Each mill average is given equal weight in determining the infestation average for the State. Infestation counts consist of the percentage of joints (internodes) bored as determined from total number of joints and joints showing external signs of borer injury. From the mill stock piles, 20 five-stalk samples selected without bias are examined on each date and at each mill. If under 10 percent of the joints are bored, infestation is considered to be very light; 10 to 20 light; 20 to 30, severe; and over 30, very severe. The percentage of crop loss for each 1 percent joints bored is conservatively estimated to be three-fourths of 1 percent.

Method used in Florida.--Surveys to determine sugarcane borer infestations in Florida are made, also, at harvesttime each year. Examinations are made in approximately 40 representative fields of sugarcane well distributed over the sugar-producing area. Individual fields are sampled by counting the total number of joints and externally apparent bored joints of 10 consecutive stalks in each of five locations. The samples are taken about 100 feet apart in the central one-third section of the field. Up to 5 percent of the joints bored is considered to be a light infestation; 5 to 10, moderate; and over 10, heavy. The percentage of crop loss for each 1 percent joints bored is conservatively estimated to be 1 percent. In Florida the average infestation is less, and the loss per unit of infestation is more than it is in Louisiana.

Determining Overwintering Mortality and First-Generation Infestation

To determine effects of climatic conditions on overwintering populations in Louisiana, surveys are made during late February. To determine first-generation infestation for an estimate of the probable infestation and control needs during the growing season, surveys are made in late May and early June.

105/ Grain and Forage Insects Research Branch, Entomology Research Division, ARS, USDA, Houma, La.

The February examinations are made in 10 parishes that have past histories of heavy borer infestations. The survey consists of dissecting cane tops and pieces of mature stalks left in the fields during the previous harvest until a total of 100 borers is recorded for each parish. The first-generation population, in terms of borer-killed dead-hearted plants, is determined by examining one 1/100-acre single row sample in each of 75 to 100 representative ratoon fields scattered in at least 10 parishes. From these counts, a figure representing the average number of deadhearts per acre is calculated for each parish. An average infestation of up to 300 deadhearts per acre is considered light; 300 to 600, medium; 600 to 1,000, severe; and over 1,000, very severe.

TOBACCO INSECTS

Determining Insect Damage on Shade-Grown Tobacco

F. S. Chamberlin 106/ and C. R. Gentry 107/

A field method of determining insect damage was developed for shade-grown cigar-wrapper tobacco at Quincy, Florida, in 1937. Its application apparently gave a fairly reliable index of the damage caused by hornworms, budworms, and flea beetles. The method was based upon the local tobacco packinghouse breakage grade system. The sales value of cigar-wrapper tobacco has advanced greatly, and the breakage-grade system has undergone some changes since 1937 but the same principles of damage determination should be applicable today.

The breakage-grade system assumes that four cigar-wrapper cuts will be taken from each uninjured leaf. Very small holes close to the margin or midrib do not prevent the leaf from being classified in the first or "uninjured" grade. Leaves having about 25 and 50 percent of their area injured are placed in the second and third grades, respectively. All injury below the third grade places the leaves in the fourth or "brokes" grade. The average percent reduction in value in the three grades is shown in the table on the following page.

106/ Deceased, formerly with Plant Pest Control Division, ARS.
107/ Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Quincy, Fla.

Average percent reduction in the value of wrapper tobacco in breakage grades 2, 3, and 4

Holes and breakage	Grade	Average selling price per pound	Average percent reduction in value
		Dollars	
Leaves average 95 to 100 percent uninjured	1	3.25	0
About 25 percent of leaf-surface damaged	2	2.44	25
About 50 percent of leaf-surface damaged	3	1.00	69
All below third grade "brokes"	4	.25	92

In the packinghouses, cured and sweated wrapper tobacco is graded for insect damage and other breakage by ordinary labor. In the field, the same grading can be performed by an inspector who must be able to differentiate between injuries caused by the feeding of hornworms, budworms, and flea beetles and the injuries produced by other causes. Discrimination between these different types of injury is performed most easily in the field.

In practice the scoring of insect injuries was performed in each field on five lots of 10 plants each. Four of these lots were located 25 to 30 feet from each of the four respective corners of the field. The fifth lot was chosen near the center of the field. The leaves on the 50 plants were first counted and then scored separately for observable injuries produced by hornworms, budworms, and flea beetles. The average reduction in value caused by the respective insects was easily computed.

Onions

Onion Thrips

F. H. Shirck 108/ and W. E. Peay 109/

Onion thrips (Thrips tabaci Linderman) populations can be determined by taking samples of onion tops and placing them in cardboard tubes that have an inside diameter of 5-1/8 inches and a height of 7 inches 110/. The tubes have cloth tops with a slip-on metal cover to close the open end. Individual samples, consisting of 10 onion plants cut off just above the ground, are placed in the tube with the butt ends against the cloth and the projecting tops cut off level with the cylinder.

If thrips populations are being determined from onion seedheads, a sample of five heads is used and the same procedure followed as for onion plants. The slip-on lid is replaced by a metal funnel having a 1-inch vertical band around its top to provide a close fit with the cardboard tube. The funnel is attached through a cork to a small jar containing a 0.5-percent solution of formalin. The thrips are separated from the sample by drying at 115° F. for 24 hours. This causes the thrips to leave the sample and fall into the formalin solution, from which they are later strained and counted. The formalin protects the thrips from molds in case the counting is delayed. The strainer also serves as a counting device. It consists of a piece of black cloth on which guidelines three-eighths inch apart are stitched with white thread and cemented to a metal ring of convenient size to be used under binoculars. Before beginning the counts, the cloth is pressed firmly on an absorbent material to draw out the excess moisture remaining in the cloth. The number of samples will depend upon the size of the field or plot.

Peas and Beans

Pea Aphid

W. E. Cook 111/

Two methods are commonly used in measuring populations of pea aphid (Acyrthosiphon pisum (Harris)), the choice of method depending upon the host plants and size of the aphid population.

108/ Retired, formerly with Bureau of Entomology and Plant Quarantine, ARS, USDA.

109/ Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Twin Falls, Idaho.

110/ Shirck, F. H. Collecting and counting onion thrips from samples of vegetation. Jour. Econ. Ent. 41(1): 121-123. 1948.

111/ Deceased, formerly with Fruit and Vegetables Research Branch, Entomology Research Division, ARS, USDA.

Sweep Net Counts

The sweep net is used in very low aphid populations, such as those occurring in alfalfa late in the summer or in peas just after the spring movement of aphids from alfalfa. A standard 15-inch collecting net is used, and a brisk sweep of about three-fourths of a circle is taken. (Two sets of samples are taken in representative parts of each field.) In taking a series of sweeps, the operator moves forward one or two steps at each sweep, to sample previously undisturbed foliage. A few exploratory sweeps are taken to determine the size of sample. In general, a sufficient number of sweeps should be taken to collect from 50 to 100 aphids, but in very low populations this may not be possible. Under these conditions, a sample of 25 or 50 sweeps should be taken.

Tip Counts

The tip count is used in general survey work on moderate to high populations. The operator walks across the field holding an open paper sack in one hand and picks tips at random with the other hand. The tips are from 4 to 6 inches long and are picked with a twisting motion of the hand so that the tip, when severed, is held over the open palm, to catch any aphids that may be dislodged. The tips are dropped into the paper bag. The paper bag is then closed, stapled, and taken to the laboratory for counting of the aphids. At the laboratory the bags are placed in a large container and fumigated with a few cubic centimeters of methyl-iso-butyl ketone for about 10 minutes. This makes the aphids loosen their hold on the plants. The contents of the bags are then shaken over a 4-mesh screen so that the aphids drop through and the plants remain. Flat black or white boards may be used to catch the aphids for counting. As with the sweep net, the number of tips per sample is varied with the aphid population. Two 50-tip samples are needed for populations much lower than one aphid per tip, while two 5- or 10-tip samples are sufficient for aphid populations higher than 10 per tip. It is generally difficult to count more than 300 to 500 aphids per sample; therefore, in high populations, the number of tips per sample should be reduced to give about this total number of aphids.

Correlation of Methods

Because of the varying conditions under which the above methods are used ordinarily, a close correlation is not possible. However, in general on alfalfa a population of one aphid per tip is about equal to 30 aphids per sweep. On peas, a population of one aphid per tip is about equal to three to four aphids per sweep.

Pea Weevil

Agricultural Research Service

Pea weevil (Bruchus pisorum (Linnaeus)) populations in infested pea fields are most often concentrated in a narrow zone around the edges, especially in larger fields. Because of this, applying control measures to the entire field is frequently unnecessary.

Parts of the field that require dusting may be determined quickly and accurately by making adult counts with a 15-inch insect net. Counts are made by sweepings soon after the first blossoms appear and before controls are applied. The inspector goes into the field in several places on each of the four sides or at intervals in an irregularly shaped field. Two or more 25-sweep collections are made at each selected location (beginning at edge of field or 100 feet inside the margin), with strokes across the upper parts of the vines spaced at one or two paces. As each collection is completed, weevils are counted and the number and location recorded on a rough diagram of the field. Inspection progresses at 100-foot intervals toward the center of the planting until no weevils are found.

In peas grown for seed, survey is made toward the center of the field to the point where weevil numbers fall below the economic level.

In an average field of peas, it is difficult to accurately establish an expected infestation rating from a given number of weevils, as determined by sweeping with an insect net, because of weather and time of season. Weather has an important effect on both yield and weevil activity. The same number of weevils produce a greater infestation in late varieties than in early varieties. A population of five weevils per 50 sweeps may cause infestation at the canning stage of 1 to 2 percent in early varieties, whereas the same population may cause infestation at the same stage of 10 to 25 percent in varieties blooming after June 15. An infestation of one weevil in 25 sweeps on the growing plants at time of blooming causes from 3 to 8 percent infestation in peas harvested for seed.

In making this survey, particular attention is given to areas in the field most likely to be severely infested including borders adjacent to wooded or brushy areas, buildings, ravines, gullies or any area where the first peas blossomed. After the initial inspection, fields are rechecked 18 to 24 hours after dusting to determine the effectiveness of the control operation.

Western Bean Cutworm

J. R. Douglass 112/

The examination of beanfields for western bean cutworm (Loxagrotis albicosta (Smith)) should be first directed toward the detection of holes in the pods by the larvae and, second, if they are found, toward the cutworm itself. Since other insects eat similar holes in the pods, the presence of the larvae must be found for positive identification. If the beans have not been cut, an examination should be made of 100 feet of row located in the center of the field and 100 feet of row located near the approximate center of each quarter of the field, involving the examination of a total of 500 feet of row per field.

To facilitate turning the vines and exposing the pods, a vine lifter (see diagram) could be used to advantage. The handle is made from 1-5/8-inch by 3/4-inch lumber and is 39 inches long. The blade is made from 1-1/4-inch by 3/8-inch lumber and is 17 inches long. If holes are noted in the bean pods, the plants should be slapped so as to knock any larvae that may be on the plants into the middle of the row. The soil under the plants should also be examined for these larvae, since they often burrow into the soil around the plants. If the bean plants have been cut and windrowed or shocked, an examination should be made of 20 feet of windrow in the center of the field and 20 feet located near the approximate center of each quarter of the field, involving the examination of 100 feet of row per field. On examining the row, the vines should be raised, shaken, turned, and placed to one side. Larval pellets drop on the soil surface, and when they are observed either under the plants or windrows, the larvae are often readily found.

Vine lifter

For the distribution and description of the insect see J. L. Hoerner's article on this cutworm 113/.

112/ Retired, formerly with Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Ft. Collins, Colo.

113/ Hoerner, J. L. The cutworm Loxagrotis albicosta on beans. Jour. Econ. Ent. 41(4): 631-635. 1948.

Aphid Populations on Potatoes in the Northeast

W. A. Shands [114] and G. W. Simpson [115]

Survey Methods in Maine

Populations of aphids in northeastern Maine are determined at intervals on potatoes receiving no insecticidal treatment and on potatoes treated commercially for the control of insects. In this area the potato plants usually are infested by winged and wingless forms of four species of aphids--buckthorn aphid (*Aphis nasturtii* Kaltenbach), foxglove aphid (*Acyrthosiphon solani* (Kaltenbach)), green peach aphid (*Myzus persicae* (Sulzer)), and potato aphid (*Macrosiphum euphorbiae* (Thomas)).

The wingless forms--ordinarily by far the more numerous on the plants--cause direct feeding damage to the potato plants and also serve as vectors for certain virus diseases of potato. The winged forms are often of more importance than the wingless forms in spreading the virus diseases within and between fields of potatoes, and they also colonize plants in widely separated parts of the field. One species of aphid may be of greater importance than another as a vector of certain of the virus diseases and in causing direct feeding damage to the potato plants. Therefore, in all aphid population counts, a record form is used to show the number of each species found on each sample unit.

Number and Location of Sample Units

Experience has shown that it is not practical to determine aphid populations in an entire potato field. Consequently, the sample units are limited to 1 square acre in each field of commercially grown potatoes examined. One hundred sample plants are located mechanically at random over the acre by a screen-grid method.

Unit and Subunits of Sample

Early in the season, when plants and aphid populations are small, the entire hill is examined. After the plants are about 8 inches high the examinations are confined to three leaves on each sample plant. The leaves are examined *in situ*, care being taken not to disturb the aphids. One leaf is located at random within each of the top, middle, and bottom thirds of the plant height or stalk length. Later, if larger numbers of aphids develop, only the terminal and the two basal (lateral) leaflets of each leaf in each of the three standard positions are examined. Typically, potato leaves have

114/ Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Orono, Maine.
115/ Department of Entomology, University of Maine, Orono, Maine.

seven leaflets--a terminal and three pairs of laterals. If still later, even larger numbers of aphids develop, the subunits consist of only half the area of these three leaflets in similar positions. All the leaf area on one side of a midrib of a leaflet constitutes a half leaflet. Detailed studies have shown that this is a valid sampling procedure. These half-leaflets are chosen so that 50 percent of them are on one side of the leaflet midrib and the rest on the other. For any one sample plant, however, the same side of the midrib for all nine of the half-leaflets is used.

Expressing aphid populations.--Populations are stated in terms of the average number of aphids of each species per plant. Winged and wingless forms are recorded separately. Except when the entire hill is used as the unit of sample early in the season, the number of aphids determined as the average is the average of those found on three whole leaves per plant. When the subunit consists of leaflets one, four, and seven, the three-whole-leaf basis is approximated by dividing the average (for the one, four, and seven leaflet basis) by 38.1 and multiplying by 100. This formula was derived from a study of aphid distribution on potato leaves. Likewise, the three-whole-leaf basis is approximated for counts involving subunits of one-half of leaflets one, four, and seven by using 19.05 as the factor instead of 38.1.

Information from surveys following this procedure permits comparisons between aphid populations at different locations, as well as among the populations of the four species of aphids involved. Because of differences in growth habits of different potato varieties, population comparisons between varieties and between years may be of less value. When made at regular intervals throughout the season in the same locations, the counts indicate locality differences in rates of population increase. Actual aphid populations per plant--when subunits of sample are involved--can be approximated by multiplying the averages for the three-whole-leaf basis by one-third of the average number of leaves per stalk and that by the average number of stalks per hill.

Green Peach Aphid on Potatoes in the Northwest

B. J. Landis and D. M. Powell [116]

Only the green peach aphid (*Myzus persicae* (Sulzer)) occurs in sufficient numbers to cause direct feeding damage to potatoes in the intermountain area of the Northwest. The extent of overwintering is indicated by the number of eggs found per 6 inches of twig in 25-twig samples taken from each of four peach orchards in February. At this time the location of 100 eggs is marked on the trees. The start of hatching and 50 and 100 percent of hatch is determined by examining those eggs every 2 weeks. This information is of most use to orchardists in planning their control program. Because of the long-growing season in some parts of the Northwest and the ability of some of the summer forms of the green peach aphid to survive most winters where there are also peach orchards, no good correlation has been shown between populations of stem mother aphids on peaches in February and March and peak populations of aphids on potatoes in June and July.

[116] Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Yakima, Wash.

The start of aphid flight from peach trees or hardy weeds in the spring, and the seasonal intensity of flight from May to October, is determined from twice a week examinations of four, or more, Moericke-type traps that are placed at ground level near potato fields. This trap consists of an aluminum stew pan 8 inches wide and 2-1/2 inches high. Chrome-yellow enamel paint is applied to the inside of the pan to within 1 inch of the top. A quart of water in each pan serves as a trapping medium. The aphids are removed for identification and counting by pouring the water through a fine-mesh wire screen funnel.

Starting when the potato plants are 4 inches high, and continuing at approximately 14-day intervals until the early crop is harvested or the late-crop plants are frosted, 50 compound leaves are picked at random one leaf per plant from the base of the plant in four fields of approximately the same planting age. Three categories of aphid abundance are obtained from the trap or leaf-sample examinations.

Classification	Number of winged aphids per trap (3- to 4-day collection)	Number of wingless aphids per 50 compound leaves of potato
Light	0 to 10	0 to 50
Moderate	11 to 100	51 to 500
Heavy	101 to over 1,000	501 to over 2,000

Potato Psyllid

R. L. Wallis 117/

To determine the abundance of potato psyllid (Paratrioza cockerelli (Sulc)) populations, adult counts are made in approximately 10 potato fields per county, selected at random and examined at 1- to 2-week intervals during the growth of the plants.

Potato psyllids are most numerous near the edges and progressively diminish in numbers toward the center of the potato fields. Adult counts are made with a 15-inch insect net of unbleached muslin. Starting at one edge of the field and working toward the center along the rows, 50 sweeps are taken at intervals of about one pace. The net is swept briskly across the tops of the plants, covering approximately two-thirds of the net opening with the tops of the plants. Sampling is continued toward the center of the field, in units of 50 sweeps, until two to four units of samples are obtained, depending on the size of the field. Counts are recorded in numbers of psyllids per 100 sweeps.

117/ Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Yakima, Wash.

Although survey records are based on adult counts, egg and nymph counts may be made, if desired, by taking 50-leaflet samples at the same location that the adult counts are made. One leaflet is taken from near the center of each of 50 plants. The leaflets are examined in the laboratory under a low magnification lens and the eggs and nymphs are recorded in numbers per 50 leaflets.

Sugarbeets

Beet Leafhopper Survey Using a Standard Sweep Net

H. Green 118/

While a sweep net is not considered as accurate as some other methods of survey for beet leafhopper (Circulifer tenellus (Baker)), it is considered faster and its use will permit a practical estimate of leafhopper populations in a given area.

In using a sweep net, similar in form and size to a standard butterfly collecting net, three important factors must be considered: (1) weather, (2) condition of the host plant, and (3) type of host plant.

Weather

Leafhoppers are not particularly active in temperatures below 60° F., lower temperatures forcing them close to the ground where they would be difficult to pick up with the net. Wind also will cause leafhoppers to remain well within the protection of the host plant. In either case it would be difficult to pick up a true representative population with a net, and collecting should be avoided under such conditions.

Condition of the Host

On occasion the host plant may be quite dry, thus forcing concentrations of beet leafhopper onto the greener plants, which should then be made the object of sweeping.

Type of Host Plant

The manner of sweeping depends on the type of host plant involved. In the case of mature Russian-thistle and perennials, as normally encountered in the fall, survey is based on the number of leafhoppers recovered in a single sharp 90° sweep of the net. On the smaller winter annuals, 3-foot sweeps of the net should be made rapidly back and forth as close to the ground as possible. Ten, 25, or 50 such sweeps, depending upon the population, should be taken. The number of leafhoppers thus recorded is based on the average number per sweep in relation to the number of sweeps made.

118/ Retired, formerly with Bureau of Entomology, California Department of Agriculture, Fresno, Calif.

In general practice, survey is accomplished by sweeping at one-quarter to one-half mile stops throughout favorable-looking areas. Except where a single sweep is used on mature thistle and large perennials, the usual practice is to take 10 sweeps. However, if the population of leafhoppers is exceedingly low, as many as 50 sweeps may be used for each check. Where 10 sweeps are used, at least 10 such unit checks at each location are customarily made.

Generally speaking, an average of five leafhoppers per 10 sweeps is considered the minimum economic population meriting treatment. However, under certain conditions, an average of two or three leafhoppers per 10 sweeps over a large area can produce damaging numbers.

During spring, survey is restricted to warm knolls with a southern exposure and sparse growth favorable to development of the spring generation. In such areas, sweeping is used to determine the need for treatment and, later, to check the time and extent of the spring flight into agricultural areas. The number of female leafhoppers at the time of checking is used to determine the time and extent of the spring flight into these areas. Such survey is usually made by using the 10-sweep unit, sweeping as close to the ground as possible.

Beet Leafhopper Survey Using Square-Foot Sampler

J. R. Douglass 119/

Spring surveys are made annually, generally during April, to determine the abundance and distribution of overwintered beet leafhoppers (Circulifer tenellus (Baker)) and their principal wild host plants in representative spring breeding areas in southern Idaho and eastern Oregon. To measure leafhopper abundance, 50 samples are taken at random at 3-mile intervals along the routes traveled where wild host plants occur. The counts are made with the Hills' 120/ square-foot sampler, which traps the insects in a cage. The kind, stand, distribution, and condition of wild host plants are recorded. The population is expressed in the number of leafhoppers per sample or per 100 square feet of weed-host area.

Beet leafhopper counts are made in sugarbeet fields with the square-foot sampler. The samples, which include more than one plant in unthinned fields but single plants in thinned fields, are taken at random along the beet rows. Generally, 100 samples are taken in each field, 25 samples in each quarter. The average population of leafhoppers is expressed in the number per sample or per beet plant.

119/ Retired, formerly with Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Ft. Collins, Colo.

120/ Hills, O. A. A new method for collecting samples of insect populations. Jour. Econ. Ent. 26(4): 906-910. 1933.

Surveys are made in September to determine the magnitude of fall populations of the beet leafhopper in Russian-thistle areas and the extent and location of such thistle areas in southern Idaho and eastern Oregon. The transect method of recording plant cover is used to determine the acreage of Russian-thistle. The number of miles traveled and the miles of Russian-thistle observed on each side of the road are recorded. The approximate number of square miles of Russian-thistle within each area is determined by means of the following formula:

$$\frac{\text{Transect miles of thistle}}{\text{Transect miles}} = \frac{x(\text{thistle area in square miles})}{\text{Total area in square miles}}$$

Quantitative samples with a 1/2-square-foot sampling fork 121/ are used in determining the population of leafhoppers. Ten fork samples are taken at each stopping point, the number of stops depending upon the area and condition of the Russian-thistle. At each stopping point, the Russian-thistle stand is determined by means of the pacing method. This consists of taking 250 double paces through the host-plant area. The number of living plants touched by the toe of the right foot in moving through an area is counted. From this figure the percentage stand is calculated; for example, if there were 125 living plants touched by the toe of the right foot in moving 250 double paces, the stand is 50 percent. The condition and height of the thistle are recorded. From this information, the areas of Russian-thistle are computed and corrected to a 100-percent stand. By using the average density of leafhoppers per unit-area and the acreage of thistle, the approximate number of leafhoppers can be determined. As an example, if Russian-thistle occupied an average of 54 percent of each acre examined and if the thistle plants were infested on an average by 57 beet leafhoppers per square foot of land surface occupied, on this basis there would be approximately 1,340,000 beet leafhoppers per acre. This survey gives the acreage of Russian-thistle and the size of the fall population of leafhoppers in the summer breeding areas. The principal breeding areas of the beet leafhopper in the Western States have been located and delimited, and the surveys are confined to these areas.

Tomatoes

Tomato Fruitworm

W. E. Peay 122/

Surveys should be conducted weekly from late June to late August in the tomato-growing areas of Utah to determine the expected populations of tomato fruitworm (Heliothis zea (Boddie)). Eight samples, each sample containing 25 compound leaves, should be taken at random in each of two fields in the various localities. A total of 16 to 20 fields surveyed over the entire area would be sufficient. Each sample is taken by beginning either at the top or at the

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121/ Lawson, F. R., Fox, D. E., and Cook, W. C. Three new devices for measuring insect populations. U.S. Bur. Ent. and Plant Quar. ET-183, 6 pp. 1941.

122/ Vegetable and Specialty Crops Insects Research Branch, Entomology Research Division, ARS, USDA, Twin Falls, Idaho.

bottom of a branch and examining both sides of all the leaves for tomato fruitworm eggs. Leaves containing eggs should be removed from the plants and the eggs examined under a hand lens to determine definitely if they are tomato fruitworm eggs. The number of fruitworm eggs per 100 leaves is then recorded. With this information as a basis, the average number of eggs per 100 leaves is estimated for the entire tomato-growing area each week.

In Utah the presence of an average of 1 egg per 100 leaves anytime during the period of fruit setting will result in 2 to 5 percent "wormy" tomatoes, which is sufficient to justify control measures.

EQUIPMENT AND TECHNIQUES

Blacklight Trap Standards for General Insect Surveys 123/

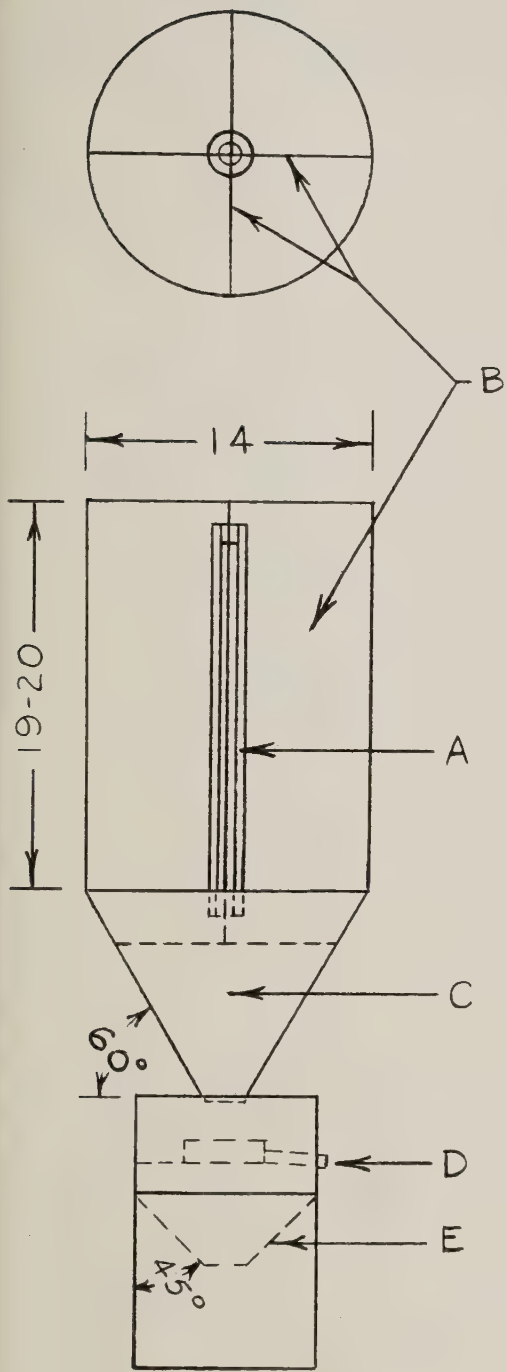
W. C. Harding 124/, J. G. Hartsock 125/, and G. G. Rohwer 126/

Insect traps utilizing blacklight lamps have become valuable tools to entomologists and others in recent years as aids in determining the time of appearance and seasonal abundance of important insect pest species.

In general insect pest surveys, several different kinds of blacklight traps are used in the United States at present. There is a definite need for trap standardization rather than the use of traps of several different designs. The use of a standard blacklight trap would aid greatly in making catches from the same area, or from different areas, more comparable.

The Committee on Insect Surveys and Losses, Eastern Branch of the Entomological Society of America embarked on a project during 1964 aimed at the recommendation of standards for blacklight traps. On the basis of the results from a questionnaire sent to 50 State and USDA workers and literature review, the Committee recommends that certain trap design standards be used in general insect survey work. The design should include: one 15-watt blacklight lamp, omnidirectional design, baffles, no fan, 10- to 18-inch funnel opening (top diameter), and a collection container capacity over 1 quart. For specifications of the standards and pertinent additional recommendations see the illustration on following page.

123/ Adapted from Ent. Soc. Amer. Bul. 12(1): 31-32, 1966.
124/ Department of Entomology, University of Maryland, College Park, Md.
125/ Farm Electrification Research Branch, Agricultural Engineering Research Division, ARS, USDA, Beltsville, Md.
126/ Plant Pest Control Division, ARS, USDA, Hyattsville, Md.



Standards:

1. Attractant--one F15T8/BL lamp (15-watt blacklight) mounted vertically. See A.

2. Position of lamp--bottom even with rim of funnel, lower lampholder below rim.

3. Four baffles (two crossed), dimensions; total width 14"; total height above funnel rim 19"-20"; clearance between inner edge and lamp 1/4"-1/2". See B.

4. Funnel-slope 60°; top diameter 14" (approx. 3/4 length of lamp); bottom opening diameter 2"; lower end inserted into top of collection container 1/4" to form drip rim for water. See C.

5. No large canopy over top of baffles (such a cover reduces catches of some species).

Additional Recommendations:

1. Wiring system showing Underwriters' Laboratories (UL) seal of approval.

2. Electrical components mounted either on side or top but if on top the area of obstruction to light not to exceed a 5" square (25 sq. in.).

3. Use of a side-emptying drain placed in cover of collection can to leave collection container unobstructed. See D. Pan diameter at least 4", depth 1", drain opening 1/2" X 1" minimum.

4. Collection container designed for use of less harzardous killing agents, such as ethyl acetate (as compared to calcium cyanide) through use of insert funnel with sealing gasket, 45° slope and 2" opening. See E.

5. Material--26 gauge galvanized steel minimum.

It should be emphasized that the Committee's chief concern is with blacklight traps used in general insect survey programs employed to determine the time of occurrence and abundance of established insect pest species, such as the corn earworm, fall armyworm, European corn borer, and cabbage looper. The Committee fully recognizes the separate need of specially designed survey traps for the purpose of detection or research.

Fly Baits and Traps

L. E. Jenkins [127]

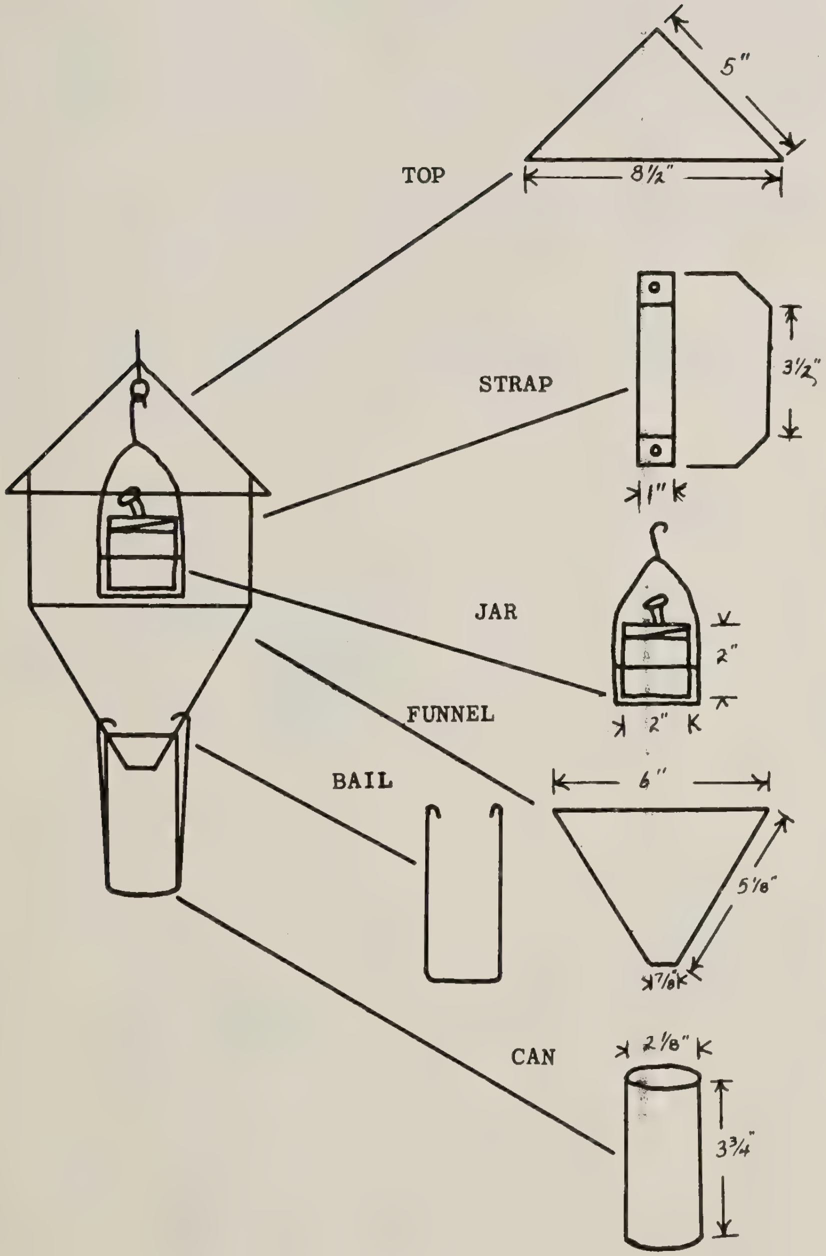
Bait traps, using several attractants, particularly hydrolyzate materials, attract a wide variety of Diptera. Bait traps are successful in determining emergence, broods, and seasonal activity of the sugar-beet root maggot (*Tetanops myopaeformis* (Röder)), seed-corn maggot (*Hylemya platura* (Meigen)), wheat stem maggot (*Meromyza americana* Fitch), and spinach leaf miner (*Pegomya hyoscyami* (Panzer)).

Materials used in bait traps for sugar-beet root maggot adults were:

Bait A--Dylox 1 oz., sugar 1 lb., water 2 qts.
Bait B--Dylox 1 oz., sugar 1 lb., water 2 qts., yeast hydrolyzate one-half oz.
Bait C--Dylox 1 oz., sugar 1 lb., water 2 qts., casein hydrolyzate one-half oz.
Bait D--Dylox 1 oz., sugar 1 lb., water 2 qts., soy hydrolyzate one-half oz.
Bait E--Dylox one-half oz., water 1 pt., protein bait No. 2 [128], 4 oz.
Bait F--Dylox one-half oz., water 1 pt., protein bait No. 7 [128], 4 oz.

Trapping procedure and results were as follows: A wood cylinder 1.25 inches in diameter by 3 inches long, or a corn cob 3 inches long, was dipped in one of the above baits and suspended over the 6-inch funnel of a Japanese beetle trap or a similar funnel-type trap. (See illustration on page 115.) Flies attracted to the bait dropped into the container under the funnel. All of the above baits caught adults of the sugar-beet root maggot. Bait A caught the most and bait D was next in numbers. Bait B, containing yeast hydrolyzate, fermented and did not attract many of the root maggot flies but did attract and kill many sarcophagids and calliphorids. The bait traps have been modified by replacing the corn cob with a wick in a 2-ounce salve jar.

127/ Department of Entomology, Colorado State University, Fort Collins, Colo.
128/ Protein bait contains amino acids.



Fly Bait Trap.

A Portable Field Cage for Insects

C. F. Speers [129]

The portable cage presented here appears to fill a gap in the cage equipment field. The units for this cage can be easily transported to the field and quickly erected over a small plant, around the stem of a tree, or in a box in the laboratory. Permanent cages are often prohibitively heavy for one man to handle; whereas the units of the portable cage are quite light. Finally, three disassembled cages take up less space in a trunk than one permanent cage.

Because all parts of the portable field cage are of a standard dimension, the cutting and machining are simplified. The units are constructed of treated lumber 2 inches square and 36 inches long. Any convenient size can be used, depending on immediate or anticipated problems. Framing for half of the units is machined with a 3/8-inch tongue along one face of each cornerpost; a 3/8-inch groove is machined in one face of the remaining cornerposts. After the material is machined, it is joined to form the units shown in figure 1.

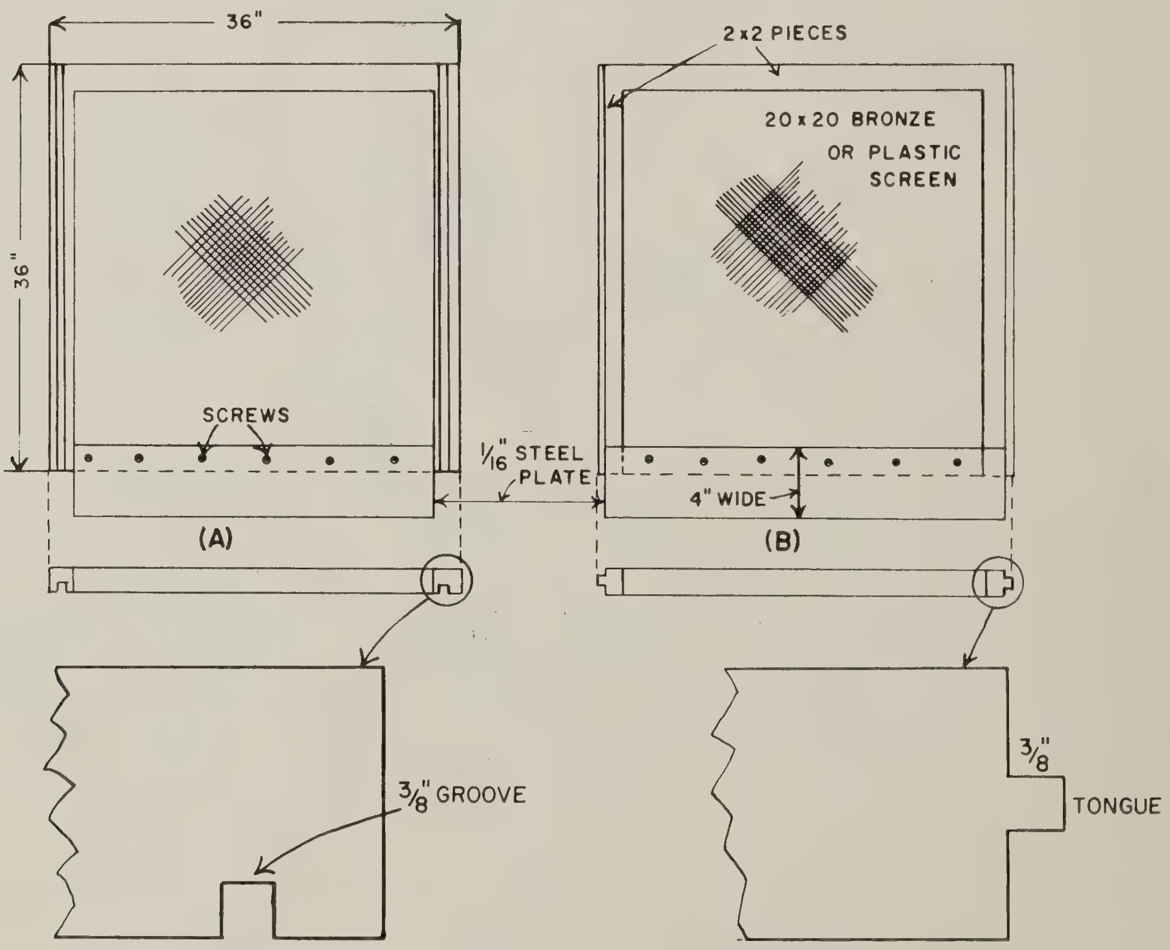


Figure 1. Units of an adjustable portable field cage.

[129] Southeastern Forest Experiment Station, Forest Service, USDA, Asheville, N. C.

The opening in each unit may be covered with either plastic or bronze screening; usually 20 by 20 mesh prevents the escape of most insects. The opening in the units may be modified to fit the need of various investigations: some may be covered with plywood, some may be covered with cloth, and some may even be provided with doors and windows.

Pieces of 1/16-inch steel plate, 4 inches or more wide, should be fastened to the bottom of each unit along its perimeter. This plate is easily forced into the ground and prevents insects and other organisms from burrowing into or out of the assembled cage. The steel plate also provides rigidity and helps anchor the cage in place.

After the units are fitted together to form a cage, a means of holding the posts tightly against each other is desirable. Loose pin hinges are quite handy for this purpose (fig. 2).

Additional tongues and grooves in the units adapt this simple cage to an infinite variety of multiple-unit cages of many sizes and shapes. In fact, with a little ingenuity the units could be used to construct something as large as a portable insectary.

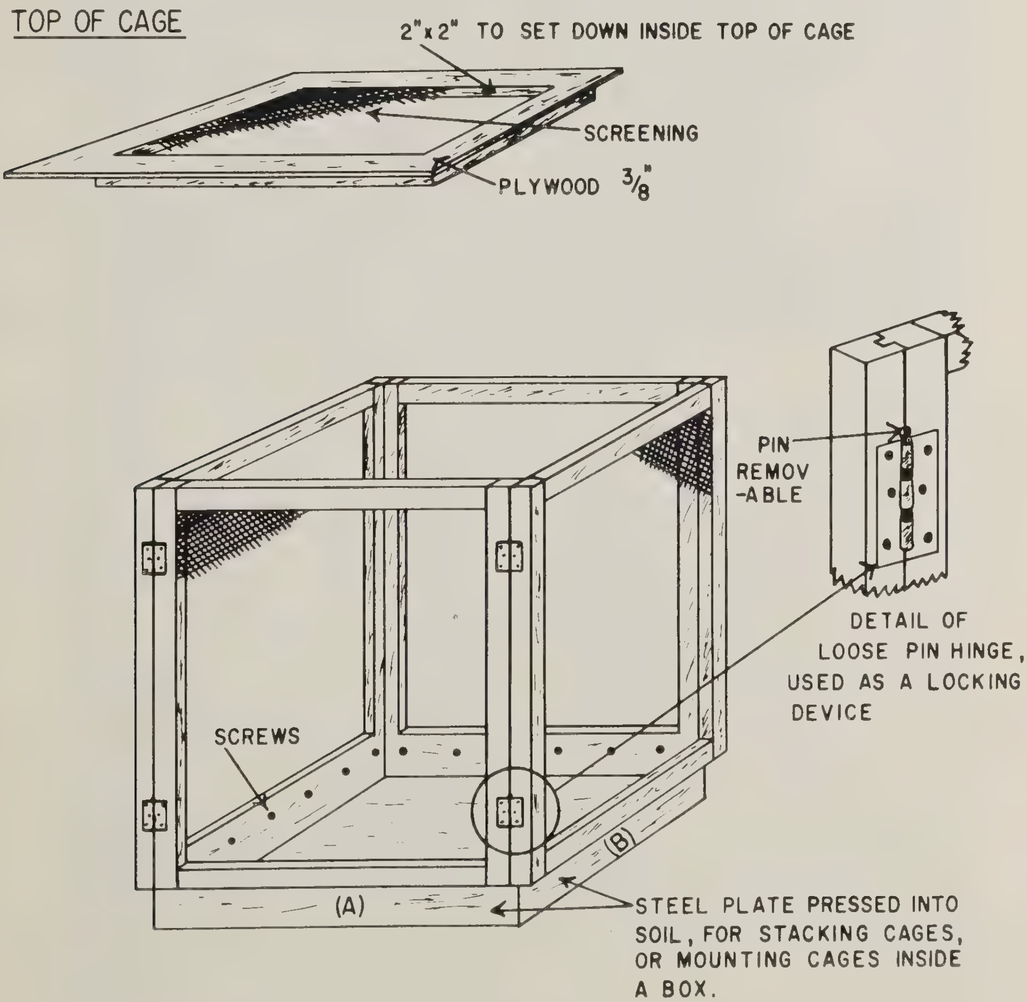


Figure 2. Cage assembly of portable rearing cage.

A Portable Rearing Cage for Insects

Bureau of Entomology, California Department of Agriculture

A simple, inexpensive portable cage for rearing out insects is shown in figure 1. A 1- or 2-quart, square, waxed, paper milk carton with the inside margin of the top and two sides cut out is placed about half-way down in a lady's discarded stocking. A rubber band is placed around the indentation at the base of the carton to hold the stocking in place and the foot is cut off. The rearing material is then placed in the cage. The excess stocking at the top is tied in a knot and is used to suspend the cage.

Figure 1. A simple, inexpensive portable rearing cage.

A Sampling Fork for Estimating Populations of Small Arthropods 130/

C. F. Henderson 131/

When studies of the biology, ecology, and control of the brown wheat mite (Petrobia latens (Müller)) were planned, it was first necessary to develop a method of estimating mite populations on various small grains. The first method tried was to dislodge the mites by brushing the host plant back and forth with the hand, and to count those that fell on a white card held beneath the foliage. These mites readily fell to the ground when the plant upon which they were feeding was disturbed. However, this procedure was too slow where large numbers of small-unit samples had to be taken quickly under comparable conditions of temperature, light, and time of day. Population estimates in plots sampled early in the day were not comparable with those taken later. Furthermore, a method was desired in which the samples could be taken to the laboratory and the mites counted under more favorable conditions. The apparatus and technique developed for these studies are described herein.

Description of Fork

In fall or winter when the plants are small, the most satisfactory population estimates may be made by counting the mites on the foliage of 1-foot sections of planted row, with a head binocular (fig. 1). In spring and summer after the plants have begun their upright growth, the mites are caused to drop from foliage to adhesive-covered glass slides held in a galvanized-iron sampling fork (fig. 2), similar to one described by Lawson 132/. This fork consists of four tines attached to a tubular steel handle that extends from the base at an angle of about 15°. Around the edge of each tine is a retaining rim. The points of the tines are beveled on the bottom to prevent them from digging into the ground when the fork is pushed along the soil surface. The slides are of single-strength window glass just large enough to slip into the rectangular chamber of the tine.

For convenience in handling, four slides are placed in an aluminum clip which has the ends turned back over the slides so that the glass surfaces will not touch when several clips are stacked (fig. 3). Two upturned stops on the back margin of the clip prevent the slides from falling out. While held in the clip, the upper surfaces of the four slides are coated by brushing with a hot mixture of mineral oil and vaseline. The proportion of the two ingredients depends upon field temperatures. The mixture should be fluid enough to spread uniformly in a thin film over the slide without showing brush marks, but firm enough not to flow under high temperatures. Brush marks greatly hinder the counting, as only those mites directly above white areas showing through the

130/ Adapted from Henderson, C. F. A sampling fork for estimating populations of small arthropods. U.S. Dept. Agr., Agr. Res. Serv. ARS 33-18, 7 pp. 1956.
131/ Retired, formerly of Entomology Research Division, ARS, USDA.
132/ Lawson, F. R., Fox, D. E., and Cook, W. C. Three new devices for measuring insect populations. U.S. Bur. Ent. and Plant Quar. E-183, 6 pp. 1941.

glass slides are counted, and the uneven refraction of light through irregular adhesive surfaces obscures the outline of these areas. Three parts of mineral oil to one of vaseline is satisfactory; the proportion of vaseline is increased with higher temperatures and decreased with lower ones. The mixture may be applied cold, but it is more difficult to avoid leaving brush marks when applying a thin film.

After the slides have been coated, they are stacked in one side of a metal slide box (fig. 4). This box has two compartments--one for carrying the clean, coated slides to the field and the other for holding the slides after the mites have been collected. Three of these slide boxes are placed in a metal case for carrying to the field (fig. 5). A large number of the slides may be coated and held indefinitely in these carrying cases for future sampling.

In a field to be sampled, a slide box is removed from the carrying case and taken to the sampling site. A clip of slides is taken from the box and rested on the flat surface of the fork. The slides, removed individually from the clip and inserted in the tines of the fork with the adhesive surface on top, are held in position by the retaining rim (fig. 6). The sampling fork is then ready for use.

Using the Fork

The fork containing the coated slides is inserted through the base of the plant at ground level (fig. 7), and the foliage is disturbed by brushing with the hand so that the mites will drop to the ground. Those that fall on the slides are held by the adhesive. The fork is then withdrawn and the slides are replaced in the clip. The bottom or outside top margin of the clip is labeled with a lead pencil as to sampling site, date, host, or other desired data. The clip of slides is then returned to the holding box, and when all the collections have been made, the box is placed in the carrying case and brought back to the laboratory for counting. The samples may be held in good condition for many days in the refrigerator.

Counting the Mites

For counting the specimens a thin transparent celluloid card is inserted between the glass slides and the metal clip. This counting card has four white areas 1/4- or 1/8-inch wide and 4-1/4 inches long, so arranged that they will coincide with the approximate centers of the four slides when the card is shoved tightly against the retaining stops. The white areas may be made with plastic paint or plastic tape. Counting is done with reflected light from an ordinary microscope lamp.

When a card containing 1/4-inch strips is used, each slide represents a sample area of 1.06 square inches, and each fork 4.25 square inches (approximately 1 inch of planted row). When a 1/8-inch strip is used, one-half of these areas are represented. No statistical differences were observed between counts made with the two areas. Other types of counting patterns may be used, such as four 1/4- by 1-inch areas placed one above the other in the center or run diagonally across the card. The differences between such patterns did not exceed 4 percent. If the number of mites present over the counting area is not sufficient for an adequate count, the entire slide may examined under lower

power. Furthermore, where low populations occur or slide-carrying space is limited, as on an extended survey, a composite sample may be taken on a single set of four slides, and so labeled. After the counts have been completed, the slides are placed in a cylindrical wire screen basket and submerged in a solvent (fig. 8) where they are agitated a few times and then allowed to soak to dissolve the mineral oil and vaseline. The clean slides may then be wiped with a rag or placed in hot water and spread out on a rack to dry. If cleaner slides are desired, they may be agitated in hot, soapy water after being removed from the solvent, and then rinsed in hot water. The metal clips are cleaned by wiping with a rag moistened with solvent, or soaking in the solvent and then wiping.

Other Uses of the Sampling Fork

The sampling fork was found to be very satisfactory for estimating populations of the spotted alfalfa aphid and various species of thrips and other insects found in alfalfa fields. However, the optimum proportion of mineral oil and vaseline varies with the insects being collected. For example, a 5 to 1 mixture retained practically all the aphids, whereas a few were able to escape when 3 parts of mineral oil to 1 part of vaseline were used. When several species are present, the proportion should be the one that will catch those insects most likely to escape. By this procedure the fork should be practicable for sampling any small arthropod attacking small grains that has a tendency to fall when the plant is disturbed. The color of the counting area on the celluloid card should vary with the color of the insect. For example, for the spotted alfalfa aphid, which is pale greenish yellow, a dark background should be used. For the brown wheat mite and other dark species a white background is the most satisfactory.

Figure 1. Counting brown wheat mites on small wheat plants in 1-foot sections of planted row with head binocular.

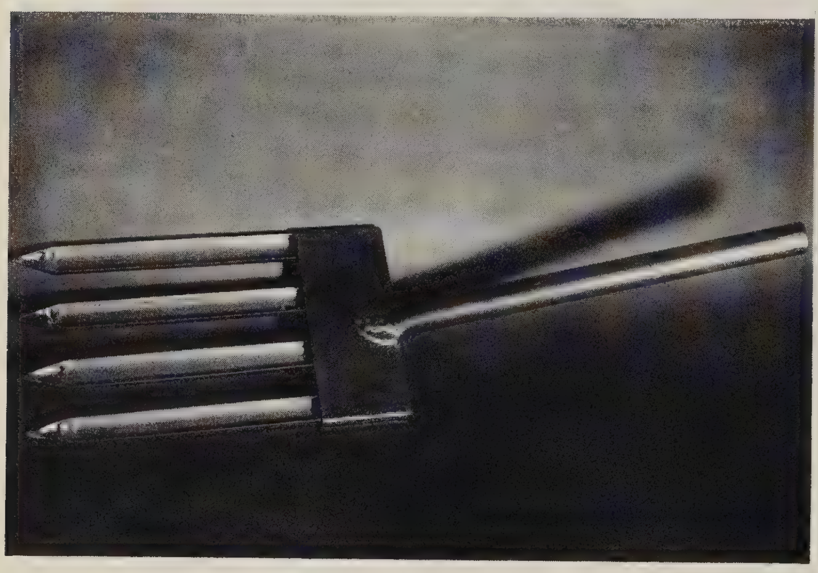


Figure 2. Sampling fork for collecting brown wheat mites from foliage of small grains for counting.

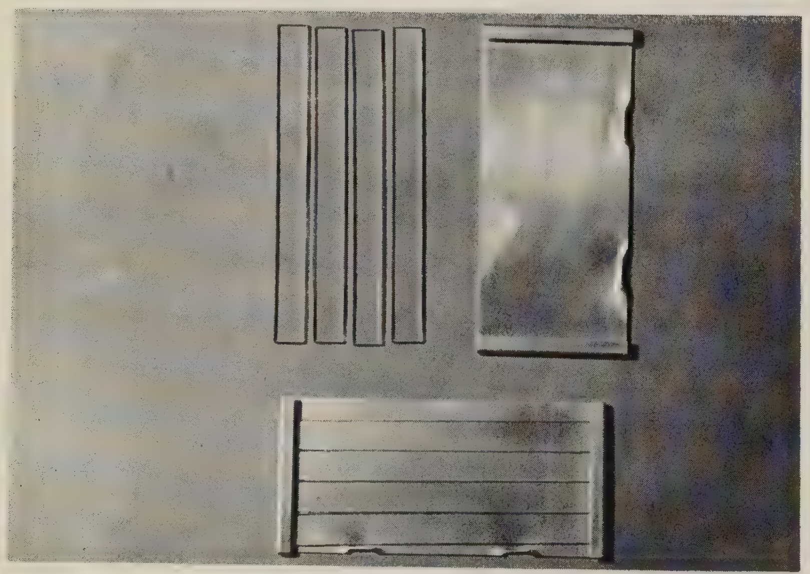


Figure 3. A, glass slides; B, aluminum clip; C, glass slides in clip ready for application of adhesive.

Figure 4. Slide box for carrying clips of coated slides to sampling site: A, front view showing empty slides stacked in front compartment; B, side view; C, front view showing slides in rear compartment after collections have been taken.

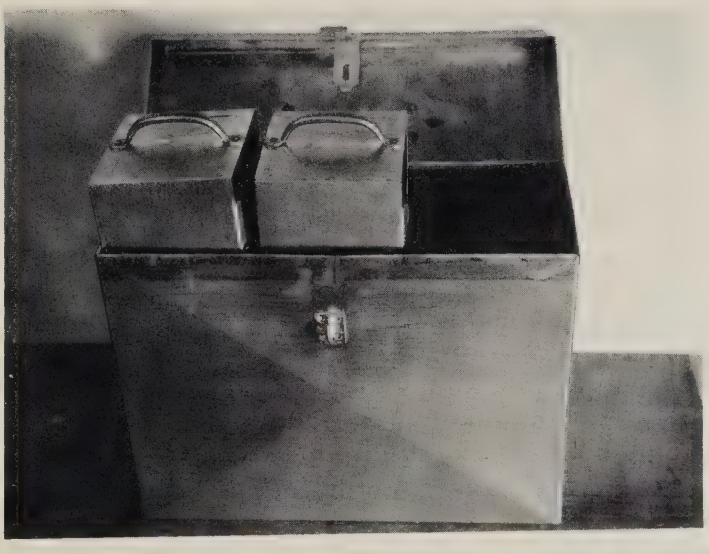


Figure 5. Carrying case for holding three slide boxes.

Figure 6. Inserting coated slides in tines of sampling fork before taking collection.

Figure 7. Sampling clump of grass for populations of brown wheat mite.

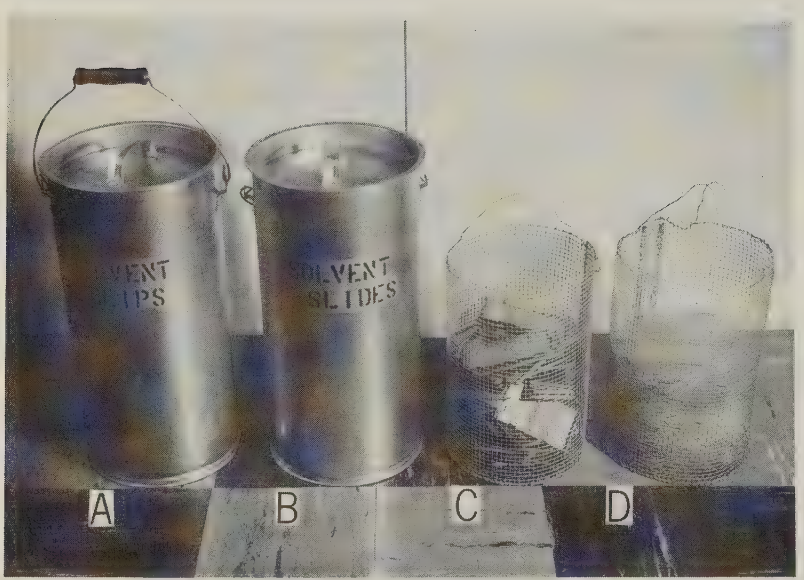


Figure 8. Apparatus used in cleaning slides: A, solvent for cleaning clips; B, cream can containing solvent for cleaning slides; C, basket of clips; D, wire basket of clips ready for soaking in solvent.

Sticky Board Traps

Plant Pest Control Division

Traps, utilizing a sticky material to catch and hold insects, have been used for years. Variations of these may be useful for numerous kinds of insect surveys. As the traps are inexpensive and easy to manufacture, regular replacement with new ones is facilitated. Reclaiming used traps has proved to be costly, except where very few are in operation.

Some of the advantages of the sticky-board traps, especially when used in large numbers, are as follows: (1) The exposure time is unlimited as they are effective as long as the barrier material remains sticky; (2) the traps function at all times of the night and day when temperatures are optimum; (3) they are compact, easy to handle and to place in operation, and require very limited space when transported; and (4) inspection is rather easy. The principal objection by users is the handling of finished traps but the free use of solvent readily overcomes the problem.

The traps may be checked in the field, moved to a central inspection station, or collected and stored for inspection at a more desirable time. Under actual field conditions when these traps were used for pear psylla, a small insect, the specimens were adequately preserved and could be readily identified when removed after a lapse of 5 months. Inspection time is reduced and efficiency improved by marking each side of the board with two black lines to divide it into thirds. Colors and lures greatly improve the effectiveness of this trap. Some collections may result from normal insect flight; but, in general, tests have shown that a board that is painted yellow with a tinge of orange will catch more insects. In special cases, where synthetic or food lures have been used, color seems to be of little significance.

The basic trap, generally 5 by 10 inches in size and one-fourth inch or less in thickness, may be manufactured from wood, plastic, or treated paper. It is imperative that the carrier will not absorb the sticky material. Suitable hangers may be made from 18-gage soft iron wire passed through a centered hole 1 inch from the top of the board. The adhesive material may be applied by hand (spatula or tile cement spreader) or by passing the boards between two rollers such as a washing machine wringer. One pound of most materials will coat 35 or 40 traps. When coating during cold weather, the consistency of the sticky material may be improved by placing the containers in a 60° to 70° F. water bath.

Specimens are readily removed from the adhesive material with a small stick or flattened object after first applying a suitable solvent directly on the specimen. When the specimens are removed, they should be placed in vials containing the solvent. After a short time the sloshing motion of the solvent will remove any remaining sticky material and the specimens are ready for determination and transfer to alcohol or another preservative.

When the sticky material is placed on a surface that has been made impervious to oily substances by means of paint, lacquer, or shellac, the effectiveness quality of the adhesive is generally retained indefinitely. Highway marking lacquer serves well for coloring traps yellow. The lacquer may be brushed, rolled, or sprayed. At temperatures below when most insect flight ceases, the average substance will still be sticky. When temperatures are near or below the freezing point, the surface becomes semitacky but returns to its original condition in warm weather. Light rains and showers do not affect the stickiness or other qualities of the substances. Heavy, beating rains that may result in white milky spots and streaks on the surface, slow up inspection. Heavy duststorms frequently cover the traps to the extent of turning them black with dirt. The affected surface may first be cleaned with solvent applied with an atomizer to aid in the inspection of such boards.

Sugar Bait for *Heliothis* Moths in Arkansas

W. P. Boyer, Charles Lincoln, and J. R. Phillips 133/

The use of sugar baits has been developed as a survey method to determine field populations of *Heliothis* moths in Arkansas. Light traps placed in forestry towers are being used to study possible migration of moths.

Sugar spray is applied to each 50th row in a field. Row length determines the number of rows selected. Total row length sprayed generally amounts to one-half to 1 mile.

Around 6 p.m. the sugar spray is applied at walking speed by using a compressed air sprayer with one nozzle held 6 inches to 1 foot above the plants. Pressure is kept relatively low to give large droplets; however, droplets can be too large, causing the spray to run off the plants. After comparing sugar concentrations of 0.75, 1.5, and 3 pounds per gallon, 1.5 pounds per gallon was chosen as a standard.

Baited rows or "sugar lines" are checked at slow walking speed, soon after dark by using a headlight.

An increase in the number of moths observed daily, Monday through Friday, has been rather significant. It is not known whether this may be caused by sugar accumulation or possible "training" of the moths.

133/ Department of Entomology, University of Arkansas, Fayetteville, Ark.

Numbers of Heliothis moths on sugar lines in the Jefferson Community, Desha County, Ark., were compared with numbers taken in a standard blacklight trap in the same area for 1964-65, as follows:

Number of Moths					
1964			1965		
Date	1,000 row feet	Light trap	Date	1,000 row feet	Light trap
6/8 to 6/5	8.2	2	5/31 to 6/3	29.83	5
6/8 to 6/12	34.9	0	6/7 to 6/10	9.70	1
6/15 to 6/19	14.7	2	6/14 to 6/18	15.07	7
6/22 to 6/25	7.0	0	6/21 to 6/25	5.17	1
6/30 to 7/3	5.8	1	6/28 to 7/2	11.76	0
7/6 to 7/10	22.3	5	7/7 to 7/9	41.27	4
7/13 to 7/17	48.9	26	7/12 to 7/16	23.20	11
7/20 to 7/24	6.5	13	7/19 to 7/23	2.17	14
7/27 to 7/31	2.2	4	7/26 to 7/30	0.81	9
8/3 to 8/7	1.7	41	8/2 to 8/5	1.53	12
8/10 to 8/14	6.3	242	8/9 to 8/13	29.96	4
8/15 to 8/19	1/	85	8/16 to 8/18	12.22	8
8/20 to 8/24	1/	2/	8/24 to 8/27	6.24	148
8/25 to 9/1	1/	71	8/30 to 9/2	13.98	105

1/ Sugar lines not run.
2/ Light trap out of order.

Moths on sugar lines are expressed as numbers per 1,000 row feet while actual numbers taken in the trap are listed. Data show that the light trap is rather inefficient in estimating field populations of moths during June, July, and part of August. During mid-August to late August, relatively more moths were taken in the light trap than were observed on sugar lines. This is thought to be due to crops approaching maturity and becoming unattractive. Sugar line data along with light trap data provide a clearer picture of the seasonal occurrence of H. virescens moths.

During May 31 through July 2 from 3.3 to 24.3 percent of Heliothis moths in the field were H. virescens. In the light trap H. zea moths were low during this period but no H. virescens were taken. After mid-August, H. virescens were taken in the light trap while none were observed on sugar lines. Sugar line data show that peak moth populations in the field occurred at approximately 5-week intervals in 1965.

Many workers over a long period have reported a 30-day life cycle in laboratory rearing at summer temperatures. The 5-week peak has helped explain a puzzling problem in that outbreaks of bollworm have occurred in soybeans in late August approximately 5 weeks after July outbreaks in cotton.

Moth peaks did not show up in light traps as distinctly as they did on sugar lines in 1965. Unpublished results of a previous study showed that peak moth numbers in light traps may appear about 1 week later than peaks of eggs on cotton. This would indicate that moths taken in light traps are older spent moths. It is known that moths of all ages are observed on sugar baits.

Factors other than populations were studied in connection with this survey. Although the full significance of shades of color of the bollworm moth is not known, it has been determined that moths from pupae which were in diapause are light in color. To further study the color factor, moths are classed as light or dark and the data recorded seasonally and by host. Moths are collected and examined to determine the number of times females have mated. These data are recorded seasonally and by host.

This method of survey apparently could be used for other species of insects. Data on other species were not collected; however, it was quite evident that moths of cabbage looper (Trichoplusia ni (Hübner)), armyworm (Pseudaletia unipuncta (Haworth)), and green cloverworm (Plathypena scabra (Fabricius)) respond to the sugar spray.

Sweep Nets

W. P. Boyer 134/

Insect collection with a sweep net is made easier by the use of a 7-dram plastic capsule vial attached to the end of the sweep net bag. When insects are to be collected for accurate counting or preserving, this adaptation 135/ eliminates the use of a killing jar, and the transfer of insects from the bag to the killing jar and from killing jar to another container (fig. 1).

To make this adaptation 135/, the end of the bag is cut off being careful that the proper length of the tip end of the tapered bag is removed. This permits the cloth to fit over the plastic vial cap. Glue is used to help hold the vial cap in place. Fine nylon string is then wrapped firmly around the cloth and vial cap, and glue is applied to the string. After the glue is dry, a hole is cut in the vial cap removing all of the top of the cap and leaving the rim of the cap around the top of the vial. (The hole should not be cut before wrapping and gluing in order to keep the vial and cap rigid when wrapping.) The vial can then be removed and replaced as desired.

When surveying or collecting or both, the surveyor has a supply of vials containing alcohol or other preservative. With an empty vial attached to the bag, the surveyor makes the desired number of sweeps, works the insects down into the vial, and removes the vial from the bag. Escape of insects can be avoided by holding the thumb over the vial. Preservative from a filled vial

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134/ Department of Entomology, University of Arkansas, Fayetteville, Ark.
135/ Adaptation designed by F. D. Miner, Entomologist, University of Arkansas.

is emptied into the vial with the collection and the vial just emptied is inserted into the bag. This method has been satisfactory except, of course, for large species.

The 5-inch net (fig. 2), also designed by F. D. Miner, has proved to be useful in sweeping alfalfa. When sweeping heavy foliage, as alfalfa, this net penetrates the voliage much better than does the standard 15-inch net. Very large numbers of insects are often taken by a sweep net in alfalfa. This results in large numbers to count when the surveyor makes the proper number of sweeps to provide field coverage. Better penetration of foliage and greater field coverage with countable numbers of insects result in more accurate sampling with the smaller net.

The financial outlay for sweep net bags often becomes expensive. The use of nylon cord in a double strand, as shown in figure 2, adds to the life of the bag. This method is also used with the standard 15-inch net with a standard bag looped around the steel ring. Varnish on the cloth loop also adds to the life of bags. In some cases both nylon cord and varnish are used.

For Figures 1 and 2, see following page.

Figure 1

Figure 2

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Agricultural Research Service
Hyattsville, Maryland 20782

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